POWER

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Human Engineering in the Plant

HUMAN engineering in the power plant is analogous to mechanical engineering, except that we are dealing with men instead of machinery. Handling men successfully means more than just having them carry out orders. It means, when the orders have been carried out, that the men will continue their work the best they know how. It means that they will not wait for the boiler inspector to tell them that the boilers need cleaning, nor until sufficient scale forms on the ammonia condensers to reduce capacity.

Efficient operation is based more on the human element than any other factor; and if this suffers, then the whole plant suffers. Every mechanical unit in a plant needs attention and adjusting to keep it up to its best efficiency. Just so with the human machine; it needs constant looking after to keep it running most efficiently. Let the human element lose its individuality, interest and initiative, and the operator will depreciate and become as a worn-out machine.

A prerequisite to successful human engineering is a good organization. An organization gives every man his place and responsibilities. It gives the chief a chance to reach every man through his immediate superior.

Every organization should have its rules which will act as signposts to keep a man on the right road. These rules must be based on the principle of fairness and justice to all and should be understood thoroughly and rigidly enforced.

To handle other men, one must practice good judgment and usually possess as much knowledge of the work to be carried on as the men who do it. Moreover, the better his morals the more respect he will command from the men.

Treating subordinates as individuals will help to bring out individuality and interest; and it must not be forgotten that all cannot be treated alike. Some can be given liberty and they will do more efficient work; others need constant probing. But as a rule all men love praise, and praising each individually for the good work he has done, will make him love his work better.

Plant convenience is another source of contentment among the workmen. Let a plant be inconvenient to repair, to clean up and to operate, and the men unconsciously become fretful and discontented.

Things that tend to break down good human engineering are just as numerous as those that tend to build it up. Parading one's authority before the men will cause them to lose their good will and fellowship. A habit of using "I" instead of "we" when something has been done, will break down the loyalty of the force.

Patience and calm thinking are required in handling men. A leader cannot afford to let his temper run loose. The easier his temper runs away with him the less calm thinking he is able to do, and consequently the less influence he will have over those under him.

A chief must be willing to work with his men when necessary. This will show that he is one of them, and it will make them feel that he is with them in their work.

When men are plentiful, it is unwise to hire and fire at random. A man should be picked to do a certain piece of work. He should be picked, not only to do the work, but to do it efficiently in connection with the other men; that is, he must not only fit in his own groove, but work with the others as a unit.

There are many things in a power plant that tend to promote good human engineering. One of the most important is educating and enlightening subordinates concerning their work. Many in responsible charge take the attitude that if they tell their men all about the work carried on, these men might in some way be in line for the formers' jobs. This is a mistaken attitude. A leader should be able to learn faster than his men; then, no matter how much he taught the men, he would always be just a little ahead of them. Moreover, when the company wishes to promote him, it immediately investigates to determine if there is another man to fill his place. If he has failed to educate a man for the place, then his own chances for promotion are lessened.

Issuing harsh and peremptory orders will break down teamwork. Constant fault finding and nagging will also breed inefficiency and is fatal to good will. It is just as necessary to point out a man's good traits as it is his faults. It is hard to approach a man concerning his faults unless that man knows his superior is fair and impartial.

After all is said and done, the successful leader in the power plant is going to be fair-minded, honest and personally unselfish in all his actions. He is the one that proves himself to be interested in the men and their problems and is willing to meet them on common ground.

—Contributed by W. A. Darter.

A Pitot Tube Designed for Use in High Pressure Pipe Lines

BY HEINRICH HOMBERGER*

THE Pitot tube as a means for the exact determination of quantities of water in motion is a very old device. Primarily, it is an instrument that measures the velocity of flow at one point in the pipe cross-section; and the mean velocity is determined by computing the average from a number of measurements taken at various points of the cross-sectional area of the conduit. The quantity of water flowing in the unit of time, or the rate of the flow, is then determined by multiplying the cross-sectional area by the mean velocity. From the time of the invention of the Pitot tube in France to the present day, it has, like all scientific devices, undergone a great many changes, and in its evolution it has reached a high state of perfection. Late in the year 1918 the Northern California Power Company, Consolidated, of San Francisco, found it desirable to determine the efficiency of the generating units installed in the five power plants then owned by the company. These plants had been constructed as the power market in the northern part of the state demanded it between the years of 1896 and 1912. None of the machinery at the time the tests were undertaken was new, and the natural wear that had taken place during the years of operation showed its influence in the efficiencies. No provision to test the units in a convenient and reliable way had been made at the time the plants were constructed, and means had to be found to do this work with a maximum of accuracy and a minimum of expenditure of both money and time. The writer recommended the use of the Pitot tube inserted in the pressure pipes as close as possible to the power house. This location is desirable in order to maintain direct communication between the men taking output readings and the men measuring the water. This will be readily understood if it is taken in consideration that for efficiency tests fractions of one per cent are of importance and that the readings at each setting have to be taken quickly because it is difficult to maintain a state of permanency in both input and output unless the unit that is under test can be operated separately and disconnected both electrically and hydraulically from the rest of the system.

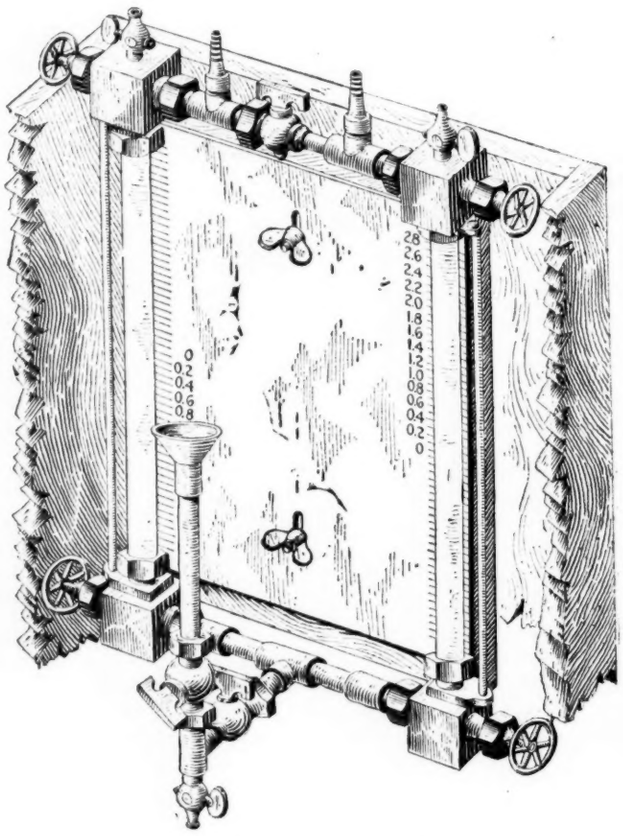

FIG. 1. MANOMETER

The pipe lines of the four plants to be tested varied in diameter between 48 in. and 78 in., and the Pitot tube had to be long enough to make a traverse through the largest pipe. Another difficulty that presented itself was that the power plants were in rather inaccessible parts of the Sierra Nevada Mountains and the work had to be done during the winter season. Therefore the apparatus had to be as compact as possible, but at the same time sufficiently rigid to stand the heavy jolting during transportation from one plant to another. The Pitot tube is inserted into the pipe through a standard corporation cock, and the only work to be done by the power company's men was to drill and tap each pipe at two points and to attach the fittings, the two openings being at points 45 deg. from the vertical plane of the pipe. In ordinary practice—that is, when only light pressures have to be dealt with—it is customary to make a U-tube from ordinary glass tubing in one piece, and the tops of the two legs of the U-tube are connected with the Pitot outlets by means of rubber tubing. This, of course, was absolutely impossible under pressure as high as those encountered, and therefore the entire manometer was made up of standard fittings with two separate glass tubes forming the two legs of the U, using a special high-pressure boiler-gage glass. The manometer was then mounted in a case with handle and leather straps so that it could be carried by one man to the point where needed and set up in the field. Fig. 1 shows the arrangement of the manometer. The scale, reading the deflection of the column in the manometer, was made out of a piece of sheet brass. It was fastened to two blocks attached to the back of the case, by means of fixed screws with thumbnuts.

As measuring fluid, carbon tetrachloride was used for low velocities and mercury for high velocities, the formulas for the deflection therefore being as follows:

$$V = C\sqrt{2gh\ (S - 1)}$$
$$= 0.84 \times 8.02\sqrt{.62} \times h \text{ for } CCl_4$$
$$V = C\sqrt{2gh\ (S - 1)}$$
$$= 0.84 \times 8.02\sqrt{12.6} \times h \text{ for } Hg$$

in which C is the constant of the Pitot tube, S the specific

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gravity of the fluid in the manometer and h the total deflection in feet.

Features of special interest which proved very valuable during the tests were a bypass between the two legs of the U-tube and a filling pipe with drain cock and funnel. Two bottles containing carbon tetra-

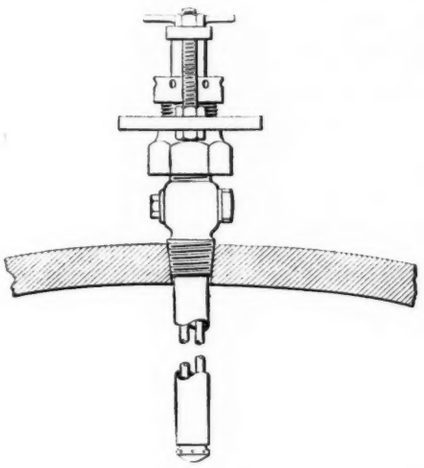


FIG. 2. METHOD OF USING PITOT TUBE

chloride and mercury were carried in the manometer case, held in place by brass straps and a distance block between the two bottles.

The Pitot Tube and Its Accessories

For the purpose of inserting the portable Pitot tube into the pipe lines in which the velocity of flow was to be measured, a stuffing box was designed, which is shown in Fig. 2. This stuffing box, of course, has to fit the corporation fitting mentioned before, a pair of which had been permanently placed in each of the pipe lines to be tested. It answers a double purpose. In the first place, it forms the water- and pressure-tight joint where the Pitot tube enters the pipe line; in the second place, it forms one of the two terminals for two threaded tension rods which are used to push the tube into the pipe line. The body of the Pitot tube which appears in Fig. 3 was made out of seamless 1-in. brass tubing, 16 gage, the outside area of which is 0.7854 sq.in. This area is under the full hydraulic head, unbalanced except for the atmospheric pressure on the outside. With an inside hydraulic pressure of, say, 200 lb., it can be readily seen that the tube could not be conveniently manipulated by hand nor could it be exactly located at predetermined points.

The unbalanced pressure is taken up by the two tension rods mentioned, consisting of ½-in. round iron threaded over the entire length. The outside end of the brass tubing is closed by a brass casting which has the double purpose of serving as the second terminal for the tension rods and of locating the inner tubes of the Pitot. These inner tubes were made of seamless copper tubing of ¼-in. O.D., 20 gage, bent at right angles outside of the terminal piece. The tension rods were each equipped with three standard hexagon nuts. The location of the Pitot head inside the pipe was easily determined by measuring the exact distance between the outside facing of the stuffing box and the inside facing of the terminal piece on the Pitot tube and subtracting this from the known distance between the terminal of the Pitot and the facing of the stuffing box at the entering position. During the use of the Pitot tube it was found that it was quite easy to relocate exactly any position that had been used before.

Tests at the South Power House

The South power plant of the Northern California Power Co. consists of one single generating unit fed by one pipe line. The rated capacity of the generator is 4,000 kva. In order to accommodate the speed of this generator, which is 225 r.p.m. and the comparatively low head of 512 ft., the waterwheel unit was designed with two independent waterwheels mounted on the two ends of the continuous generator shaft, which runs in two bearings. Each waterwheel is equipped with a needle regulating deflecting nozzle under the control of a Lombard governor. The regulating needles are operated by handwheels and the necessary reduction gear.

In back of the stationary part of each of the two nozzles is a gate valve, and a Y-connection joins the two gate valves with the terminal piece of the pipe line. The pipe line is laid on the hillside; it is supported by concrete piers and only the upper half is exposed, the lower half being embedded in the ground. The nearest suitable place in the pipe line for the corporation fittings was found about 150 ft.

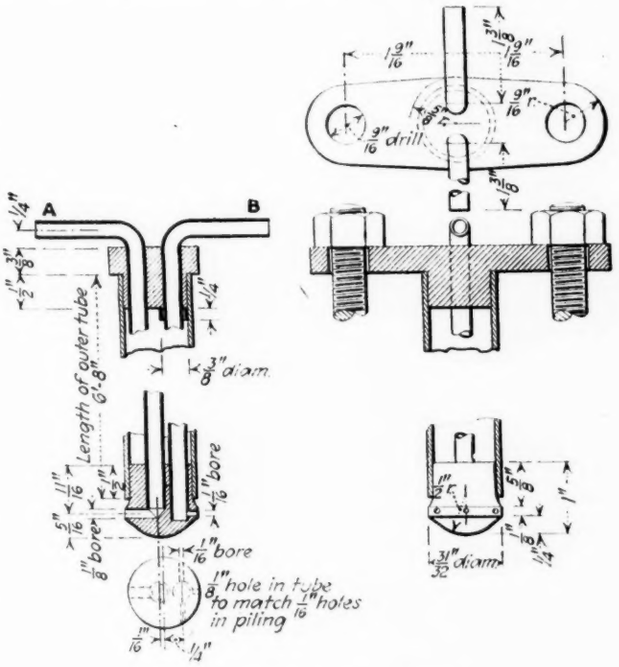


FIG. 3. PITOT TUBE DETAILS

above the power house. A temporary scaffold was erected on both sides of the pipe to support the Pitot tube and to place the box containing the manometer. It was a simple matter to have one of the power-house operators manipulate the Pitot tube when the traverses through the pipe were made. The results of the test appear in the table, while the traverse readings are given in Fig. 4.

Four readings were taken in intervals of three minutes for each setting, with an interval of about ten

minutes between settings in order to re-establish a condition of permanency in the flow of the water in the pipe line.

Tests at the Coleman Power House

The Coleman power house, as previously mentioned, contains three main generating units, each of a rated capacity of 4,500 kva., direct-connected to a Francis turbine of the single-discharge type operating under a mean effective head of 475 ft. There are three bearings to each unit. The power plant receives its water supply through two pipe lines. The main shutoff gates are outside the power house and are of the hydraulic piston-operated type. The center unit is connected to the pipe lines by means of a Y-pipe placed above the shutoff gate and takes its water from either pipe line, by means of branch connections joined to the pipe lines by saddle castings.

The three turbines are exactly alike in general design, but during the seven years of operation they had been subjected to different degrees of wear and also had been overhauled, but not all in the same fashion. It was therefore desirable to test each of the three units. This necessitated equipping both pipe lines with fittings for the Pitot tube, and in order to ascertain whether any difference in the pressure would affect the results, the fittings for the west pipe were placed about 500 ft. above the power house and the fittings for the east pipe were placed about 700 ft. below the forebay. It was found that the Pitot tube operated equally well under both high and low pressure.

The methods employed for the test were otherwise identical with those employed at the South plant, and the tabulated efficiencies obtained for the three units are given in the table.

The low efficiencies can be attributed in the first place to considerable wear of the runner edges and also to leaks in the stuffing boxes of the wicket gates. The latter defect was easily remedied by repacking the stuffing boxes. For the worn runners, which are steel castings, it was recommended to put them back to their original shape by electric spot-welding and subsequent chipping and filing. Inasmuch as the company had the electric welding equipment and sufficient experienced help, this method should prove less expensive than replacing runners. Had the runners been made of bronze or cast iron, it would have been impossible to build them up by the spot-welding method, and this point might be taken in consideration when new power plants equipped with high-head turbines are planned.

While this article is written primarily to acquaint the profession with a special high-pressure Pitot tube, it may be well to call attention to the advisability of equipping power plants with permanent measuring devices which can be used not only for the customary acceptance tests, but also for checking the performance of the hydraulic prime movers at regular intervals. This gives the owners of the plant an opportunity to keep a record of the behavior of the machines; furthermore, it will bring to their attention any sudden change caused by a possible break or obstruction in the turbine and give them an opportunity to estimate from the loss of output how much money can be reasonably expended for repairs or replacements in order to keep the power-plant equipment at a sufficiently high state of efficiency. It is astonishing that in the twenty-five years of hydro-electric practice in the United States so little attention has been paid to this feature. No steam plant of any size or importance is operated year in and year out without occasionally checking the input by fuel measurements, analysis of the combustion gases and indicator diagrams on the steam engines, or equivalent methods for ascertaining the efficiency of steam turbines. That similar methods have not been adopted for hydro-electric plants and also for large pumping plants can be explained only by lack of knowledge on the part of those who are responsible. With

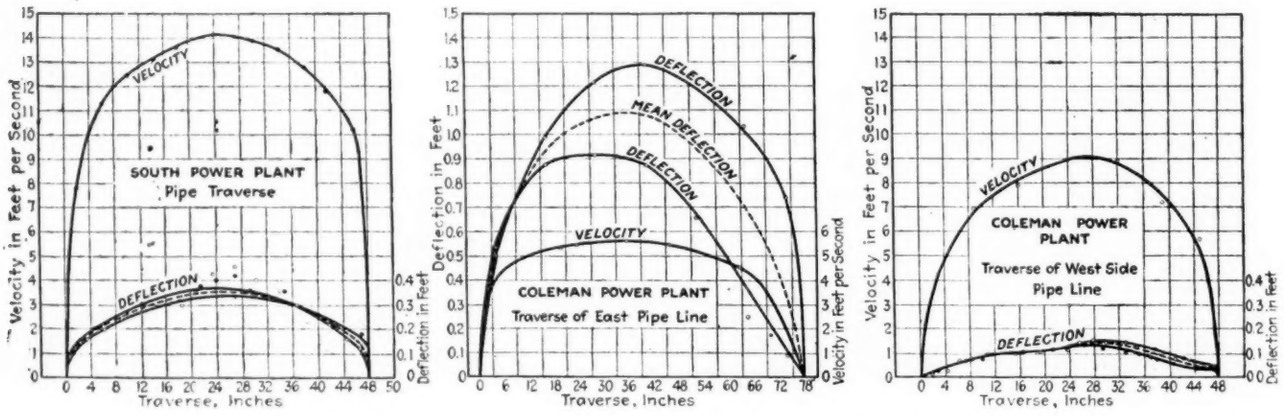


FIG. 4. PITOT READINGS ACROSS PRESSURE LINES

EFFICIENCY TESTS USING PITOT TUBES

Nom. Load, Kw.	Quantity of Water Sec. Ft.	Eff. Head, Ft.	Input, Hp.	Output, Hp.	Water Wheel Efficiency Per Cent	Water Taken by Wheels
Tests at "South"						
4,500	156	507.9	9,000	6,276	69.8	2
4,000	140	511.9	8,130	5,595	68.8	2
3,000	111.5	516.3	6,520	4,415	67.7	2
2,000	84.5	518.2	4,950	3,195	64.6	2
1,000	46.8	520.8	2,760	1,915	69.4	1
500	33.2	521.7	1,957	1,208	61.8	1
Tests at "Coleman"						
Unit No. 1						
5,000	173	477.5	9,375	6,870	73.2	...
3,750	131.5	481	7,160	5,300	74.2	...
2,500	97.2	483	5,320	3,520	66.2	...
1,250	56	482.5	3,060	1,950	63.8	...
Unit No. 2						
5,000	168	466.38	8,850	6,820	77.4	...
3,750	128.5	478.94	6,990	5,120	73.3	...
2,500	97	476.65	5,250	3,415	65.2	...
1,250	60.1	480.46	3,275	1,880	57.5	...
Unit No. 3						
5,000	164	472.4	8,790	6,975	76.9	...
3,750	126.3	477	6,830	5,315	77.7	...
2,500	98	482	5,360	3,545	66.2	...
1,250	55.2	484.5	3,070	1,965	64.3	...

the advance hydraulic engineering has taken in the last decade, there is no excuse for such negligence, and the writer has greeted with great satisfaction the establishing of a committee on power-plant testing by the American Society of Mechanical Engineers, which has in preparation a test code for hydraulic plants.

While a Francis weir can be installed in almost every plant, the writer does not believe that this method of measuring water, so much favored in this country, is the ideal one. In the first place great difficulties spring up when the weir is to be used for very large quantities. In the second place the determination of a number of necessary correction factors is something about which the last word has not yet been spoken. Experts disagree on these points, and a permanent measuring device and its handling should be foolproof and simple. For the same reason the writer does not recommend the chemical method of gaging water. There are too many possibilities of errors which are bound to be entirely overlooked unless an experienced expert is called in every time a gaging is to be made. The venturi meter, as improved by Clemens Herschel, is a wonderfully ingenious device, and the recording and indicating apparatus available in connection with it is perfected to a very high degree, but as a permanent structure in a large power plant or pumping system, one great drawback is the possibility of obstructions in connections between the venturi throat and the indicating and recording instruments, the presence of which will not be readily apparent. Furthermore, a venturi meter entails a loss of head and a loss of head means a loss of power and, consequently, a constant loss of income. The diaphragm method, as invented by the late Professor Anderson, of Stockholm, Sweden, is a very efficient device for accurate water measurements. It can be handled by inexperienced men, and if equipped with the necessary electric recording instruments, it is practically foolproof provided the diaphragm apparatus itself and the measuring canal are maintained in a good condition. The chief objection here is the rather great expense of such an installation.

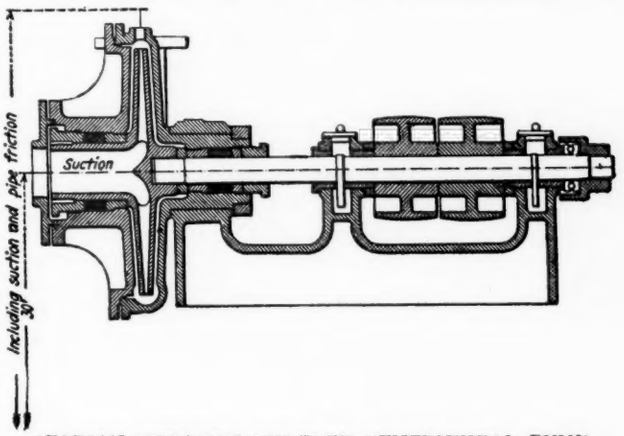
Therefore, out of the number of devices that are available to measure water in power and pumping plants, the writer from his experience believes a well-designed Pitot tube with a suitable manometer should be given the preference over everything else—first in point of accuracy, second in point of foolproofness, and third in point of limited expense.

[The reader's attention is called to the Gibson method of measuring water flow in penstocks described in *Power*, March 22.—Editor.]

Wilfley Centrifugal Pump

An interesting modification has been lately introduced in centrifugal pump design by the Wilfley Company, Ltd., Salisbury House, London Wall, E. C. 2, and is illustrated in the sectional view shown. The chief feature of this pump, says *Engineering* (London), is in the impeller, which embodies a suction passage that effectually separates the suction and delivery sides and prevents all leakage from one to the other. The hollow impeller end is carried in a packed gland, of which the friction is relatively small, and the effectiveness of the design will be realized from tests that have been made.

The pump tested had an impeller 12 in. in diameter, the blades having an angle of approximately 20 deg. The interior diameter of the suction end of the impeller was 1⅜ in. The suction and delivery pipes were 2½ in. and 2 in. The maximum efficiency obtained was 58 per cent, this including the effect of the kinetic head of the water in the delivery pipes. Neglecting the latter, the efficiency under normal working conditions would have been 3 to 4 per cent lower. If, however, allowance had been made for belt losses, the efficiency would be increased to 4 or 5 per cent. The friction loss of the suction gland, bearings and belt amounted to 0.3 hp. at 1,000 r.p.m. and 0.6 hp. at 1,500 revolutions per minute.



SECTION THROUGH WILFLEY CENTRIFUGAL PUMP

The high vacuum obtained with the special form of suction impeller with a barometer of 35.5, is as follows:

Pump R.p.m.	Suction in Ft. of Water
740	21
780	26
970 to 1,400	31
1,590	33

This 12-in. impeller pump actually gave a maximum delivery of 111½ gal. per minute, lifted to 125 ft. at 1,500 r.p.m. and 193 gal. to 53 ft. at 1,320 r.p.m. These test figures show that the principle on which the design is based is an interesting and important one.

Corrosion of Soft Metals

The commercial soft metals include aluminum, tin, zinc and lead. It has been shown previously—Bureau of Standards Scientific Paper No. 377—that a type of deterioration designated as "intercrystalline brittleness" may occur in lead under certain conditions whereby the metal crumbles to a coarse crystalline powder. The individual grains of this powder retain all the intrinsic properties of lead, but the bond between the grains has been destroyed.

During the last year a series of corrosion tests has been carried on to demonstrate to what extent such deterioration may occur in other soft metals. The intercrystalline brittleness appears to be largely dependent upon the purity of the metal, and in the pure materials used in the test very slight evidence of such deterioration was obtained. A series of stress corrosion tests has been conducted to supplement Scientific Paper No. 377, and it has been shown that the simultaneous application of tensional stress to a specimen while corrosion is in progress is a powerful adjunct to deterioration by "intercrystalline brittleness." This is of practical importance, inasmuch as lead, because of its great weight, is often subjected to very considerable stress while in service. Thus the tendency to corrode and become embrittled is accentuated.

Largest Stationary Diesel Engine in the United States

Nordberg 2,000 B.Hp. Vertical Diesel Engine of the Valve-in-Head Scavenging Two-Stroke-Cycle, Single-Acting Type. Four Power Cylinders, 500 B.Hp. Each. Scavenging Pump and Air Compressor Driven by Crankshaft. Engines To Be Direct-Connected to 1,350-Kw. Alternating-Current Generators To Supply Electrical Service to Copper Mines

THE Nordberg Manufacturing Co. of Milwaukee, has constructed and is preparing to ship to a customer a 2,000-b.hp. Diesel engine, this being the first of four units of this size that the company has on order. The engine is of the vertical full Diesel two-stroke-cycle type, with scavenging valves in the head, four power cylinders of 500 b.hp. each and scavenging pump and air compressor directly driven from the crankshaft. Two of these engines are going to Mexico and the second pair to Arizona. They will be direct-connected to 1,350-kw. alternating-current generators to supply electric power for copper mines.

These engines are the largest of their type ever built for stationary use in this country and in power per cylinder exceed any Diesel engine designed for stationary or marine service in the United States. As stated before, the engine has four power cylinders, each giving an output of 500 b.hp., with a mean effective pressure of 61.5 lb. per sq.in. at a speed of 120 r.p.m. This particular design can be built with three, four, five or six power cylinders, developing from 1,500 to 3,000 b.hp., respectively. The marine engine is built in sizes of four and six cylinders, with a speed of 110 r.p.m. and with a respectively longer stroke.

From the accompanying illustrations the general design of the Nordberg Diesel engine can be observed. Fig. 1 shows the four working cylinders and at the end opposite the flywheel the vertical scavenging pump and a three-stage air compressor. Alongside the engine a large header for distributing the scavenging air is prominent, and to the right at the top of the engine, the suction silencer for the scavenging pump projects above the top platform. It will be noticed from this illustration that the engine is of the open-frame and crosshead design, the power cylinders being cast separately and mounted on cast-iron columns. This design gives ready access to the crankshaft, bearings and all reciprocating parts. The crankcases, however, are in-

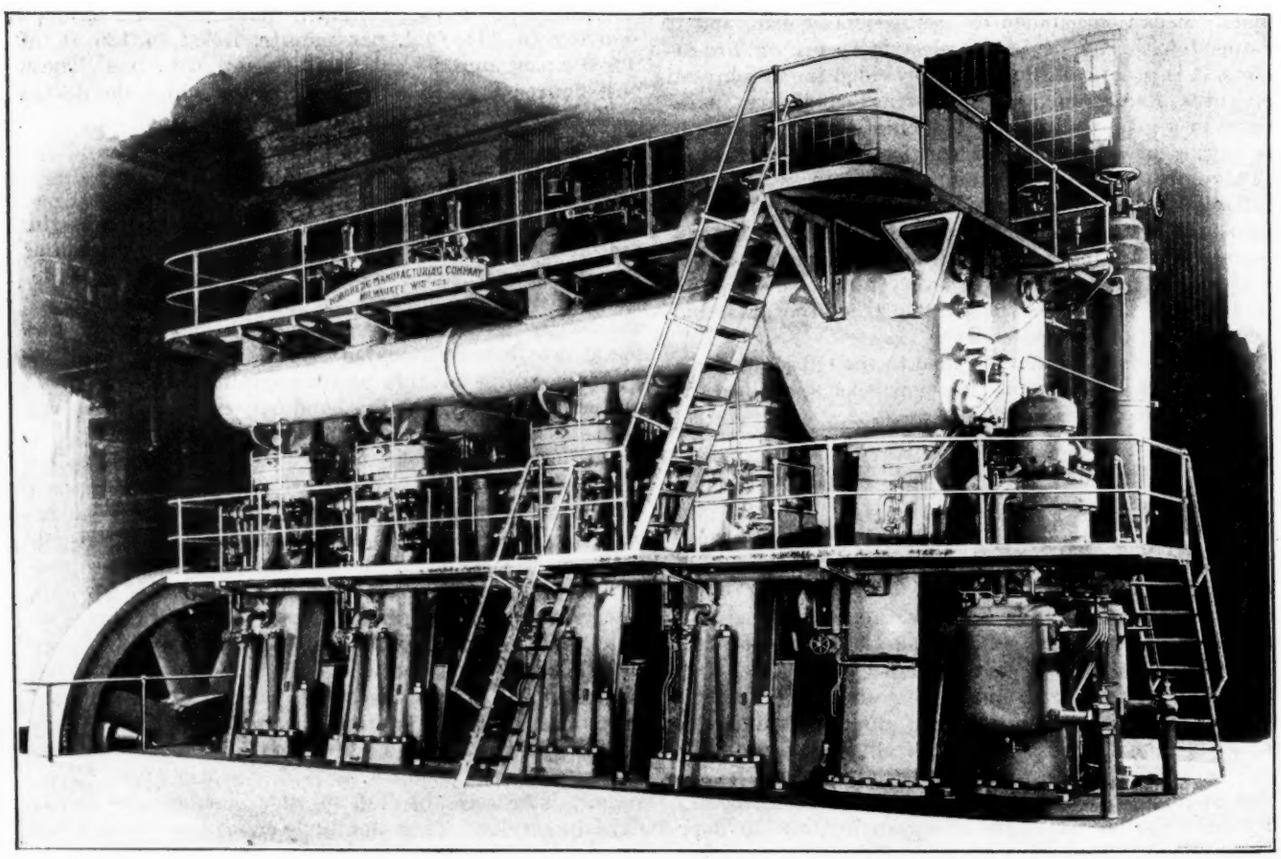


FIG. 1. NORDBERG 2,000-HORSEPOWER TWO-STROKE-CYCLE DIESEL ENGINE

closed to a certain height by means of removable hoods and covers of planished steel to keep the lubricating oil within the bedplate of the engine. In the Diesel engine accessibility is as essential a feature as is a low consumption of lubricating oil.

Reference to Fig. 4 will show that the bedplate has a closed pit in which the lubricating oil is collected, the latter being drawn out and passed through a filtering system before it is returned to the bearings. The bedplate of the engine is of cast iron, is made up in five pieces, and contains all the main bearings for the shaft. As indicated by the same view, the cylinders are bolted separately to the columns supporting the cylinders, thus transmitting the piston load to the bedplate. Each cylinder is fitted with a liner forming the cylinder proper. This liner is removable and is heavy enough for reboring. The exhaust ports are located around the entire base of the liner and permit the use of a fuel high in sulphur since the gases do not come into contact with valve seats, etc. The cylinder head is water-cooled and fitted with plugs for cleaning the inside of the jacketed space. It carries the four scavenging valves, fuel-atomizing valve and the air-starting valve. Fig. 2 shows the arrangement of these valves, the fuel-atomizing valve being in the center and the scavenging valves arranged concentrically around it.

The engine is provided with crossheads, which allow the pistons to be of the two-piece type. To the water-cooled piston head is attached the piston trunk, which, owing to the crosshead guidance, can be of a loose fit, thereby avoiding the danger of seizing. Cooling water for each piston is independently regulated. Water from the supply main passes first through a swing joint

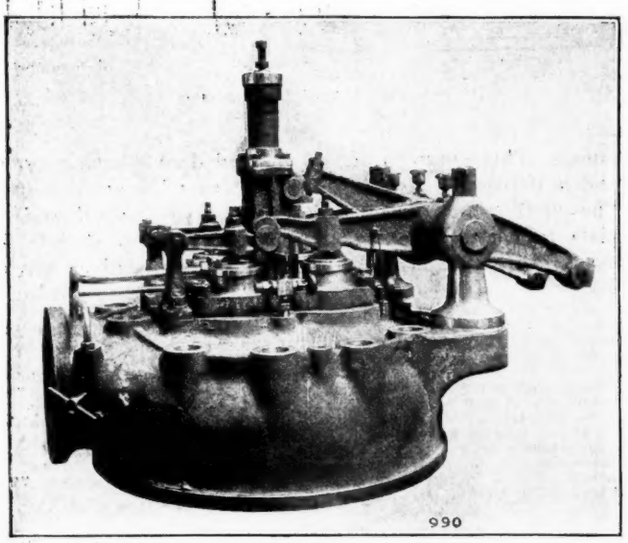


FIG. 2. CYLINDER HEAD, SHOWING FUEL AND SCAVENGING VALVES

into the hollow crosshead pin and piston rod on its way into the piston head. It returns by the way of a pipe in the hollow piston rod and through the crosshead pin and swing joint on the opposite side of the entrance. In Fig. 3, *A* is the connection to the crosshead and *B* the cooling-water inlet in one case and the outlet in the other. This swinging joint is made from material that will resist the corrosive action of water. All strains that would ordinarily be thrown on the packing are taken up by bearings. The excellent service which this device has given on the Nordberg Diesels indicates that there will be no water leakage.

Fig. 4 shows that the crosshead runs on double guides which are separate from the columns and are water-cooled. Cast-steel shoes are bolted to the crosshead proper, and provision is made for easy adjustment. The crankshaft, shown in Fig. 5, is built up of U-sections

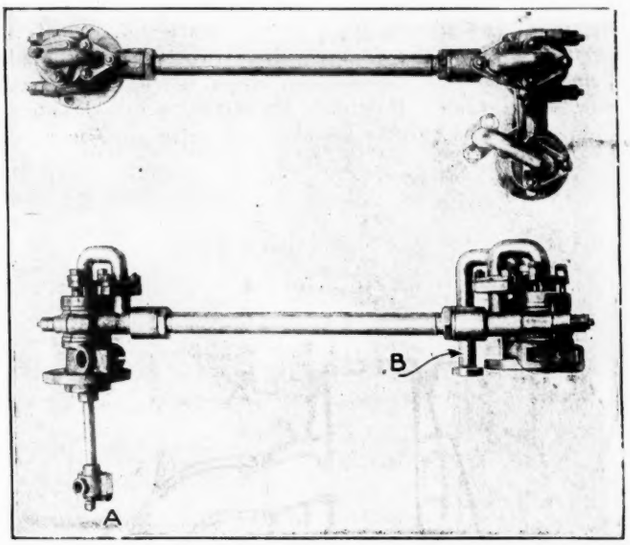


FIG. 3. SWING JOINT FOR ADMITTING AND REMOVING PISTON COOLING WATER

and straight pieces. The sections are turned and pressed together. Including those portions devoted to flywheel and generator, the complete shaft is approximately fifty-one feet long. The crankshaft for the four power cylinders is in two sections, one for each pair of cylinders, with the cranks at 180 deg., the sections being set so that these two crank planes are at an angle of 90 deg. The two sections are interchangeable. The shaft section and webs are turned and bored slightly tapering and are keyed after being pressed together at ordinary room temperature.

Fig. 6 shows the fuel-atomizing, scavenging and air-starting valves. The first-named consists of a central stem or needle valve, held to its seat by a spring. This needle valve is surrounded by a concentric sleeve, the annular space between the needle and the sleeve giving passage to the blast air. On the external circumference of the sleeve are longitudinal grooves through which fuel oil passes on its way to the cylinder. Near the discharge end of the fuel-atomizing valve, the oil encounters atomizing plates through which it is forced by the blast air, whose pressure, depending upon the character of the fuel oil used, is higher than that of the compression in the cylinder, the latter ranging from 480 to 500 lb. The fuel oil enters the cylinder through a special flame plate, and the high temperature, due to the compression, ignites the oil immediately after it enters the cylinder. The fuel-atomizing valve is operated by means of a rocker lever actuated from the camshaft at the proper point in the piston stroke. The valve is held to its seat by a spring on which the compression is adjustable from the top. The construction indicates that the fuel valve can be easily removed for inspection without dismantling any of the sur-

rounding parts, but it is seldom necessary to remove a self-cleaning valve of this type.

Reference to the same drawing, Fig. 6, shows the air-starting valve, which is of the balanced type with a comparatively light spring holding it closed. The valve is actuated from the camshaft, but can be thrown in or out of action by an ingenious hand device. The engine is started by means of compressed air, which is stored in air bottles at a pressure of 1,000 lb. For marine service the pressure is reduced to approximately 350 to 400 lb. before the air enters the cylinder. By means of the special hand device mentioned, the air is turned off and the fuel on, the transfer being made gradually so that there is no shock in changing from one to the other. It is only necessary to use the starting air on two cylinders. The fuel valves of the other

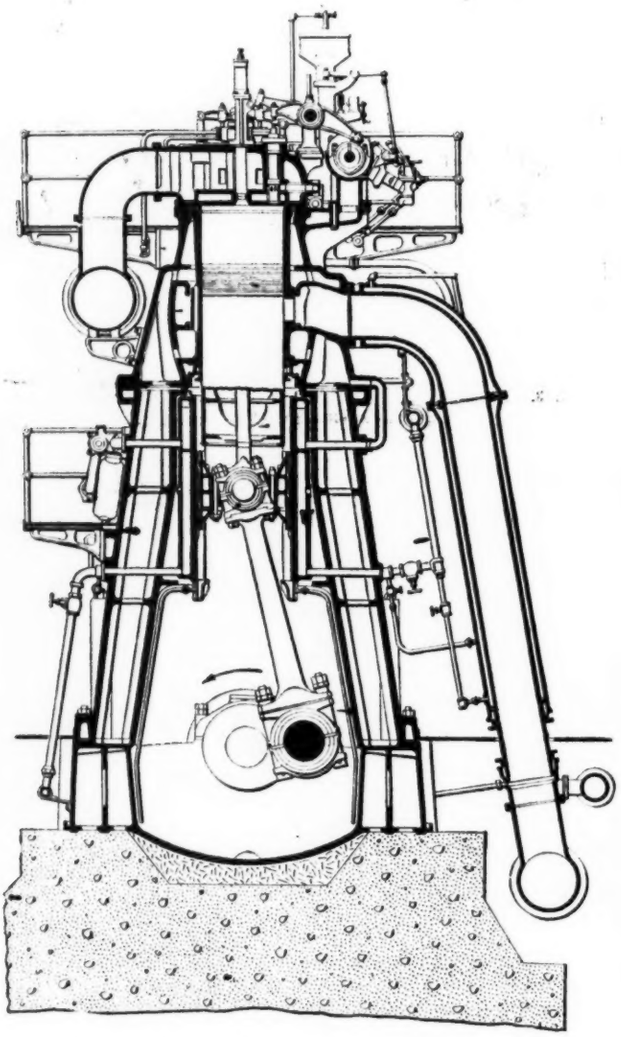


FIG. 4. SECTIONAL VIEW THROUGH ENGINE

cylinders are in action on starting and begin to fire as soon as the engine turns over.

Each cylinder has its own fuel pump, which is of the plunger type. Two plungers operate in one body, mounted between each set of two cylinders on the upper gallery of the engine. The plungers are connected to a round crosshead common to both, the latter being driven by an eccentric from the camshaft. The quantity of oil delivered to the cylinders is regulated by a sensitive centrifugal governor acting on the fuel-pump bypass valve by closing it earlier or later, according to the speed of the engine. The control of this bypass valve is effected by means of a relative motion given from an eccentric on the camshaft and by the governor, which acts upon a regulating shaft and times the closing of the bypass valve.

In line with the four power cylinders, and at the end opposite the flywheel in Fig. 1, is the scavenging

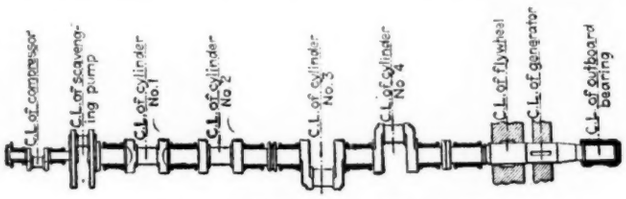

C.L. of compressor
C.L. of scavenging pump
C.L. of cylinder No. 1
C.L. of cylinder No. 2
C.L. of cylinder No. 3
C.L. of cylinder No. 4
C.L. of flywheel
C.L. of generator
C.L. of outboard bearing

FIG. 5. BUILT-UP CRANKSHAFT

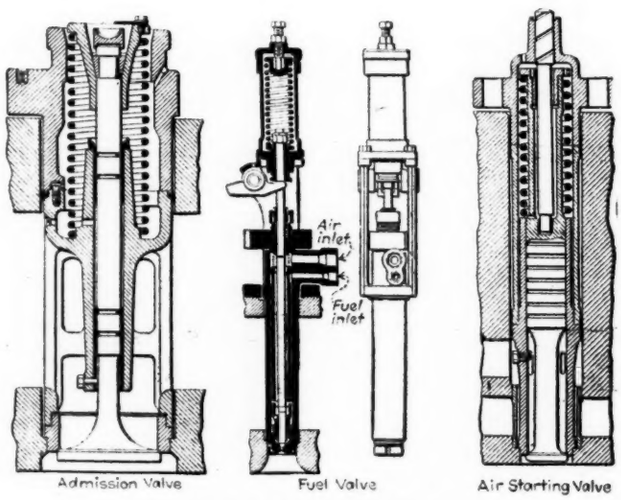


FIG. 6. VALVE SECTIONS

pump. This pump is of the vertical double-acting type and is driven by a separate crank from the crankshaft. The suction and discharge valves are of the automatic plate type. Scavenging air leaves the pump at 4 to 6 lb. pressure and passes through the large header shown

MAIN DATA OF THE ENGINE

Bore of cylinder, in.	28
Stroke of piston, in.	44
Number of power cylinders	4
Shaft or brake horsepower per engine	2,000
Revolutions per minute at full load	120
Piston speed per minute, ft.	880
Mean effective pressure (referred to b.hp.), lb.	61.5
Flywheel diameter, ft.	16
Approximate height of engine from floor line, ft.	23
Net weight of complete engine, lb.	650,000
Length of unit including generator, ft.	51.75
Width of bedplate, ft.	12

in Fig. 1, to the power cylinders of the engine. The air enters each cylinder through the four scavenging valves, of which mention has been made.

Air for starting the engine and for atomizing the fuel oil is supplied by a three-stage compressor of the crosshead type, which is driven from the crankshaft and is located at the end of the unit. As shown in the sectional view, Fig. 7, the low- and high-pressure cylinders are above the piston and the intermediate cylinder in a recess below the piston head. This arrangement of staging insures a good balancing of the piston loads. Air is taken into the low-pressure cylin-

der through the suction silencer. The quantity is controlled by means of a hand-operated regulating valve. Between each stage the air passes through tubular intercoolers having sufficient surface to cool the air back to atmospheric temperature. In leaving the high-pressure cylinder, the air passes through an aftercooler to the blast bottle, from which the air is distributed to the cylinders for atomizing the fuel oil or to the two starting bottles from which air is drawn to start the engine.

For both suction and discharge, circular plate valves are used. These valves are automatically operated by the air pressure and are held to their seats by light springs. The compressor cylinders are water-jacketed, the water entering through the air coolers and passing on through the jackets of the intermediate, low- and high-pressure cylinders, leaving the compressor at the top from the high-pressure cylinder head. The blast pressure maintained is varied to suit the character of the fuel oil used, a thin oil requiring considerably

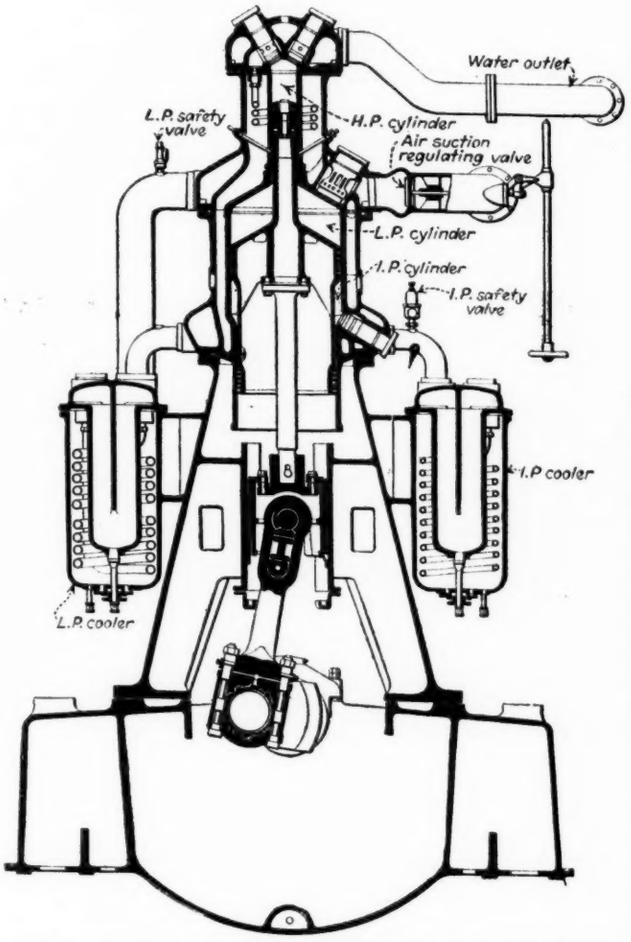


FIG. 7. SECTIONAL VIEW THROUGH AIR COMPRESSOR

less pressure than a heavier grade. A full complement of safety valves is installed to protect this high-pressure equipment.

In the accompanying table are given the main data of the engine. It will be noticed that the cylinder bore is 28 in., the stroke 44 in., and the speed 120 r.p.m., giving a piston velocity of 820 ft. per min. The engine weight, including flywheel, air bottles, piping, platform and all auxiliaries such as filters and pumps, is approximately 650,000 lb., or 325 lb. per brake-horsepower of rating. The over-all dimensions, including flywheel, generator and outboard bearing, are 51 ft. 9 in. in length, 19 ft. 3 in. in width and 23 ft. in height from the crankshaft center. The engine base is but 12 ft. wide. Using the extreme dimensions, the floor area covered by the entire unit will approximate 1,000 sq.ft., reducing to 0.5 sq.ft. per brake-horsepower of the engine, or 0.74 sq.ft. per kilowatt of generator rating.

Polarity of Single-Phase Transformers

BY J. B. GIBBS

The term polarity, as applied to a battery or a direct-current generator, means that one terminal has a definite positive potential while the other has a definite negative potential. A transformer, however, is used on alternating current and this definition obviously does

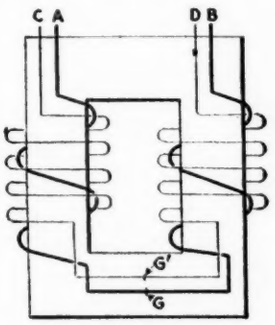


FIG. 1. DIAGRAM OF TRANSFORMER WITH SUBTRACTIVE POLARITY

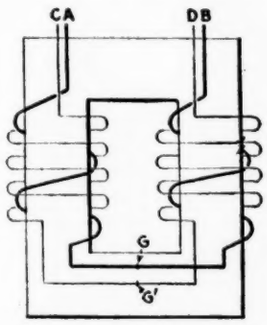


FIG. 2. DIAGRAM OF TRANSFORMER WITH ADDITIVE POLARITY

not apply, for each terminal of the transformer is alternately positive and negative as the current in the circuit alternates. When used in this connection, polarity refers to the relative direction of the voltages in the primary and secondary circuits at any instant, and therefore depends on the arrangement of the windings and the location of the leads. When the transformer is wound so that the adjacent high-voltage and low-voltage terminals are both positive or both negative at the same instant, the transformer is said to have subtractive polarity; and when a high-voltage terminal is positive at the instant when the adjacent low-voltage terminal is negative, or vice versa, the transformer is said to have additive polarity. This is more fully explained later.

Consider a core-type transformer wound as shown in Fig. 1. The heavy line *AB* represents the low-voltage winding, and the light line *CD* the high-voltage winding. The terminal *A* must therefore be positive with respect to *B* at the instant when *C* is positive with respect to *D*, since both start around the core in the same direction. If one of the windings is reversed, as shown in Fig. 2, and the leads are still in the same locations, the terminal *B* will be positive with respect to *A* at the same instant when *C* is positive with respect to *D*, for if we follow the low-voltage winding from *B* to *A* and the high-voltage winding from *C* to *D*, we will have gone around the core continuously in the same direction. In such a transformer the high-voltage leads are generally brought out of the coils on the opposite side of the core from the low-voltage leads, and the arrangement shown in Figs. 1 and 2 is chosen merely for simplicity.

The polarity of a transformer is ascertained by connecting one low-voltage lead to the adjacent high-voltage lead, as shown in Fig. 3, impressing potential on the transformer and measuring the voltages. If the voltage from C to A is greater than the voltage from C to D, the polarity is said to be "additive," and if the voltage from C to A is less than the voltage from C to D, the voltage is said to be "subtractive." Either of the arrangements of windings shown in Fig. 1 or Fig. 2 may be used in a transformer having either additive or subtractive polarity externally, depending on whether the leads are crossed or not between the points where they

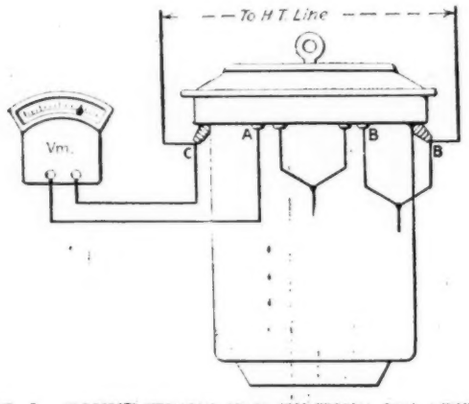


FIG. 3. CONNECTIONS FOR TESTING POLARITY

leave the coils and the points where they go through the case.

The American Institute of Electrical Engineers, the National Electric Light Association, and the Power Club, the last-named an association of electrical manufacturers, have agreed on a system of marking transformer leads so as to indicate the polarity. As applied to single-phase transformers this consists in marking the high-voltage leads H_1, H_2, H_3, etc., in the order in which they leave the winding, and similarly marking the low-voltage leads X_1, X_2, X_3, etc. The letter H_1 is applied to the high-voltage lead that leaves the case nearest to the upper left-hand corner looking at a plan view of the case and facing the low-voltage side of the transformer (lead C, Fig. 3). Letters are applied to the low-voltage leads so that when H_1 and X_1 are connected together, regardless of the location of X_1, the low voltage will subtract from the high voltage. For example, in Fig. 1, if lead C is marked H_1, lead A must be marked X_1 because it starts around the core in the same direction and will therefore have the same relative polarity. Similarly, in Fig. 2, if lead C is marked H_1, lead B must be marked X_1. Fig. 4 shows the lead lettering for a transformer with subtractive polarity and Fig. 5 the corresponding lettering for additive polarity. The great advantage of this system is that when transformers are to be paralleled it is unnecessary to make a polarity test. This is especially valuable in the case of distributing transformers, as the practice of various manufacturers differs in regard to polarity, some building distributing transformers of additive polarity and some of subtractive. Power and instrument transformers are generally of subtractive polarity.

The relative direction of the two windings also has a bearing on the voltage stress on the insulation between the high- and low-voltage windings, although this is of no practical importance in transformers whose low voltage is less than 4,600 volts. If a transformer is connected to a single-phase line that is free from grounds or which has its neutral solidly grounded, the middle point of the transformer winding will be at ground potential just as though the windings in Figs. 1 and 2 were grounded at the points G and G'. This is the ideal operating condition. If an end coil of the low-voltage winding is adjacent to the end coil of the high-voltage winding that has the same polarity, the real voltage stress between them is evidently the difference between their potentials above ground; that is, the voltage stress on the insulation at this point is $\frac{1}{2}E_1 - \frac{1}{2}E_2$. This condition is shown in Fig. 1, where the A end of the low-voltage winding is mechanically adjacent to the C end of the high-voltage winding and of the same relative potential. The voltage from C to A is evidently equal to the voltage from C to G' minus the voltage from A to G. But if an end coil of the low-voltage circuit is adjacent to the end coil of the high voltage having opposite polarity, the voltage stress on the insulation is $\frac{1}{2}E_1 + \frac{1}{2}E_2$. This is the condition in Fig. 2, where the A end of the low-voltage winding is mechanically adjacent to the C end of the high-voltage but of the opposite polarity, and the voltage from C to A is the voltage from C to G' plus the voltage from A to G. In a transformer whose ratio is 23,000 to 6,900, for instance, the voltage stress on the insulation between windings during operation would be $\frac{23,000}{2} - \frac{6,900}{2} = 8,050$ volts with the arrangement shown in Fig. 1, while it would be $\frac{23,000}{2} + \frac{6,900}{2} = 14,950$ volts with the arrangement, Fig. 2.

Under actual operating conditions it is seldom that both high-voltage and low-voltage lines are entirely free

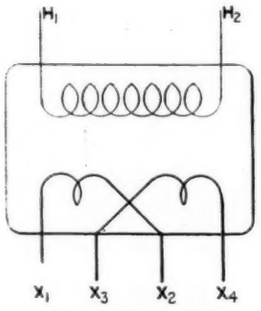


FIG. 4. SUBSTRACTIVE POLARITY TERMINAL MARKING

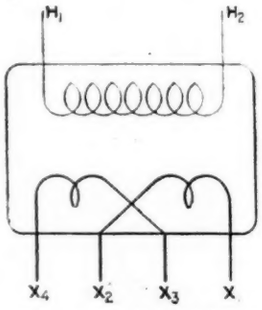


FIG. 5. ADDITIVE POLARITY TERMINAL MARKING

from grounds; and any condition may exist, from the ideal state described, to the worst possible voltage stress, which would occur when H_1 and X_2 or H_2 and X_1 were grounded at the same time. If this occurred, the worst stress that could come on the insulation between primary and secondary in a transformer wound like Fig. 1 would be the full voltage of the high-voltage winding. In a transformer wound like Fig. 2 the corresponding stress would be the sum of the high and the low voltages.

Usually, the leads will be brought out of the case to give subtractive polarity when the windings are arranged as in Fig. 1 and additive polarity when arranged as in Fig. 2, so, in general, it may be said that if the lower voltage is 4,600 or more, a transformer with subtractive polarity is preferable.

Maintenance Department Methods—III*
Distributing the Costs

By HUBERT E. COLLINS

THIS subject is of interest to all manufacturing establishments as well as to many office buildings where power is employed. The maintenance-department costs are usually charged to that department alone without distributing them among the manufacturing departments as they should be. Instead of a direct overhead charged against the works as a whole, these costs can be distributed among the departments equitably and become a legitimate manufacturing cost added to those of each department.

The maintenance-department costs are also often loaded with items that it is difficult to allocate, and if this department has not kept strict account of what is chargeable to it, it becomes easy to add a few extraneous items in the absence of outside objection. By the method here outlined this situation is avoided and the various items of cost are distributed where they rightfully belong.

It will be noted that with this method the maintenance department becomes separate and distinct in the factory organization and is rightfully charged with its proper quota of expense, which is that remaining after all the other departments receive theirs.

The organization of the maintenance department gives an idea of what the direct charges against it should be and is amplified as follows:

Maintenance-Department Charges

Power-Plant Costs—The power plant is a producing member of the maintenance department. It produces steam and electrical energy.

The steam may be used direct for power, heat and various factory purposes, or for the production of electrical energy.

These costs must be kept separate for the boiler room and engine room respectively.

Boiler-room costs should embrace the following items: Cost of fuel delivered to storage, cost of fuel delivery from storage to boiler room, total cost of fuel to boiler-room floor, wages of firemen and water tenders, wages of boiler-repair men, wages of labor and fireroom engineer, general supplies, repairs, light, power, general expense, depreciation, insurance (including fire, boiler and explosion), taxes, steam for feed pump, total cost of steam production.

Engine-room costs should embrace the following items: Wages of all engine-room attendants, cost of steam for main units and auxiliaries (at the rate of cost of steam to the boiler room), cost of any power for electrical auxiliaries, general supplies, repairs, light, power, general expense, depreciation, insurance, taxes, total costs.

These two subdivisions of the power plant should also have the complete record of the Monthly Analysis as given under the head of Power Plant Records. (Mar. 15 issue.)

General Maintenance Costs—Under this head should come maintenance department electricians, plumbers, steamfitters, tinsmiths, labor, carpenters, millwrights, elevator operators, janitors, cleaners, watchmen, and very often the first-aid assistants.

Where the separate departments of the works keep departmental help of any of these classes, the same is charged direct to the department aside from the maintenance department.

Distribution of Maintenance-Department Costs

The functions of the maintenance department organization show how the costs should be accumulated and they should be distributed with the following understanding: The boiler-room costs should be distributed as follows:

Steam for the use of the engine room should be charged there at the cost price in the boiler room.

Steam for heat should be charged at the boiler-room rate to each department in the works on the basis of radiating surface in each department for heat. This requires that a record of heating hours per year be kept for the works.

Steam for departments in the works for factory purposes should be charged at the boiler-room rate direct to each department.

If there are engine-room costs, there is also some kind of power production, and this production must be charged to the departments in one of several ways.

Electrical energy either manufactured or purchased by the maintenance department, should be charged to the department as follows: Power to be charged at the cost rate to each department on the basis of rated horsepower in motors. If separate recording meters are used to measure the current in each department, this work is simplified; light to be charged at the cost rate to each department on the basis of the wattage rating in each department's lamps. Recording meters will also simplify this work. In charging energy for light, a record of lamp hours must be kept if meters are not used.

The costs of gas, fuel oil, water or any like commodity must be charged off to each department direct and should be metered direct. If not metered, then a calculation must be made of the amount of each going to each department on the basis of flow for given-sized pipes, average pressure, etc.

In order that this method of maintenance-department accounting may be more clear, we will take three typical examples, which will cover the ground. Each example will have some points covered in a different way from the others.

In no case is the equipment for gathering all the data for completely accurate cost distribution present. A study of these articles will make plain the good of complete equipment in this respect in every factory and at the same time the value of such a system of accounting.

Example Number One

In this example the accounting department wishes to distribute as many of the maintenance-department costs among the departments of the works as possible.

There are complete power-plant records, so that this section can be charged with its own expense. We have

*This is the third and last of a series of three articles on the subject by Mr. Collins. The first, "Keeping the Power Plant Records" was published in the March 15 issue, and the second, "Organization and Scope," on March 22.

not, however, the meters necessary to allot to each department the exact amounts of electricity, steam, air, gas or water.

We can estimate the percentage of the costs to go to each department or which should have been charged during the past year. The accounting department will have to take these percentages as a basis of charge to the departments for a year hence, at the end of which the current year's record will give the new percentages to charge for the next year.

For the current year the costs each month as they come in will be charged off at the following rates for the items named:

All electrical current in these works is purchased and the boiler plant produces only steam.

The feed water to the boilers in this plant is metered with a recording meter, and all the coal is weighed each day, and the accounting department keeps a record of all expenditures.

From this it is found that the boiler room produced 66,571,190 lb. of steam for the past year at a total expense of $52,336.56.

Heating Costs—Of the amount of steam produced for the year just past we estimate that 35,472,000 lb., or 54 per cent, was used for heating. This amount was estimated from the total amount of radiation in the works in square feet times the amount of steam evaporated per hour per square foot times the total heating hours for the year.

The heating then cost 54 per cent of $52,336.56 or $28,261.74 for the year.

This $28,261.74 for heat will then be charged off to the departments of the works in amounts proportional to the known amount of heating radiation in each.

Electric Light and Power Charges—In this works all electric current is purchased. The bills for lighting and for power for each month of the ensuing year can be charged off to the departments according to a table which is computed from the percentage each bears to the total.

This table includes the wattage of small electric fans which are used on the lighting circuits in the summer. The percentage given will charge the fans off in the course of the year.

Gas Costs—The maintenance department estimates the following table of gas charges from the size of feed pipe to the department, average pressures in the mains and the number of hours per year the departments use the gas. Use the percentages in table for charging off the total costs each month for the ensuing year.

GAS CHARGE TABLE

Bldg.	Floor	Department	Cu.Ft. per Year	Percentage
2	1	Piston ring	599,040	0.0325
1	1	Wheel room	1,797,120	0.0977
8	1	Hardening room	172,224	0.0093
6	2	Grinding-boring	99,936	0.0054
3	4	Light assembly	701,280	0.0379
4	5	Racing	99,936	0.0054
2	5	Motorcycle repair	598,592	0.0323
6	5	Tool room	1,497,600	0.0822
3	2	Motor base	2,058,592	0.1220
3	1	Maintenance	99,936	0.0054
Office	1	Dispensary	75,060	0.0040
6	1	Sand blast	95,936	0.0054
10	1	Blacksmith	2,558,592	0.1490
2	2	Sheet Metal	2,745,792	0.1590
3	5	Tube bending	1,068,700	0.0685
3	5	Brazing	3,228,624	0.1840
Total cubic feet of gas per year for works			17,496,940	1.0000

Water Costs—The total amount of water used in the works for one year equalled 7,427,502 cu.ft. Of this amount the boilers are charged with one-half of the total amount of feed water, the other half being in the returns or water used over, so that of the total amount of water used in the works the maintenance department is charged with the cost of one-half of the feed water to the boilers for one year.

Bubbler drinking fountains of the type installed use 2.3 gal. of water per day of nine hours per operative.

Toilets use 2 gallons per day per operative.

There were 1,732 operatives and a 300-working-day year.

On the basis of the foregoing data we have the following use of water for the year: Feed water from mains, 532,570 cu.ft.; drinking water, 159,344 cu.ft.; toilets, 138,560 cu.ft.; other uses, 6,597,028 cu.ft.; total for year, 7,427,502 cu.ft.

Need for More Water Meters

By the estimates given we see that by far the greater part of the water used is not accounted for. This serves to show that more metering should be done or at least a more careful estimate of amounts of water used in each department should be made following the plan of apportioning the gas uses in this example.

As it stands, we can charge the maintenance department direct with the feed-water cost.

The amount of cost of the drinking water and water for toilets can be charged off on the basis of number of operatives in each department.

The balance cannot be charged off until more data are gathered.

That this would pay is evident from the example of the cooling water for two air compressors. Assuming that water is fed to the jackets in ½-in. pipes with an average pressure of 50 lb. on the city mains for 300 nine-hour days of the year, we find that 411,480 cu.ft. of water is used and then wasted in this one place alone per year.

It is also evident that it would pay to re-use this jacket water in some other place, as it would be good for many uses after leaving the jackets of the air compressor.

Example Number Two

In this example the total costs of the power plant are charged off to the different departments of the works. We know the amounts of steam used in the departments for heat, japanning and other purposes. The power-plant expense is used for these purposes alone and the electric current used is all purchased. We estimate for heating 3,080 hours per year and 4,992 heating hours per year for the japan kilns.

The list of power-plant expenses and the cost of purchased electric current is as follows:

Cost of coal delivered	$13,158.25
Cost of coal handling	3,355.25
Total cost of coal delivered to boilers	$16,513.50
Cost of wood to boilers	1,227.84
Total cost of fuel to boilers	$17,741.34
Rent of power house	1,609.68
Labor (engineer and firemen)	4,758.69
Supplies	53.39
Water for boilers	42.57
Upkeep	2,362.15
Total power-plant expense	$26,587.82
Cost of electric current purchase	$10,388.83

The power plant produced 46,780,386 lb. of steam for the aforementioned expense.

We purchased 566,433 kw.-hr. for the year at the cost stated for electric current.

We apportion out these expenses to the departments in the works as follows: Heating factory I, 0.15; heating factory S, 0.25; dry kilns, 0.03; japan kilns, 0.57; total 1.

As the dry kilns and japan kilns are each separate departments, they can be charged direct the foregoing amounts.

Factory I and factory S have several departments each, and the percentages of cost for each are computed from the amount of radiating surface, average steam pressure and the heating hours for the year, to get the total steam used in each department.

Electric-Light Charges—The percentage of electric-current charge for each department was based on the previous year's figures, of 117,120 kw.-hr. for lighting and 502,224 kw.-hr. for power.

To get the lighting apportionment, we first get the lamp wattage in departments and the total for the factory as follows:

LAMP WATTAGE TABLE

Factory I Dept.	Wattage	Factory S Dept.	Wattage
1	5,610	11	5,785
2	2,700	12	2,175
3	1,050	13	6,965
4	4,165	14	2,375
5	6,805	15	2,450
6	3,520	16	5,550
7	1,895	17	1,815
8	750	18	1,375
9	.....	19	1,800
10	.....	20	840
	29,510		31,130

	Watts
Factory I	29,510
Factory S	31,130
Electric sign	11,000
Power house	1,200
General offices	2,995
Total	75,835

If current were being used in each department alike for light, the department quota could be apportioned as in Example One. This is not the case, however, and we find the following to be the condition: Factory I uses light 3 hours per day, 309 days; Factory S uses light 6.5 hours per day, 309 days; the sign uses light 5 hours per day, 365 days; power house uses light 10 hours per day, 365 days; general offices use light 3 hours per day, 309 days. Then the percentage chargeable to the divisions is:

Factory I. $\frac{29510 \times 3 \times 309}{1000} = \frac{27355}{117120}$ kw.-hr. per year = 0.233.

Factory S. $\frac{31130 \times 6.5 \times 309}{1000} = \frac{62534}{117120}$ kw.-hr. per year = 0.536.

Sign. $\frac{11000 \times 5 \times 365}{1000} = \frac{20075}{117120}$ kw.-hr. per year = 0.17.

Power House. $\frac{1200 \times 10 \times 365}{1000} = \frac{4380}{117120}$ kw.-hr. per year = 0.037.

General Offices. $\frac{2995 \times 3 \times 309}{1000} = \frac{2776}{117120}$ kw.-hr. per year = 0.024.

The sign, power house and general offices are separate accounts in themselves and are chargeable with the given percentages of the total light bills. This can be charged off monthly or yearly as the average hours per day hold each month of the year.

For the departments in the two factories we subdivide the amount used in each department into the amount used by each factory.

Example: Department 1, Factory I, has a wattage of 5,610, while the entire wattage of the factory is 29,510. This makes Department 1 have 0.19 of the factory wattage. The factory uses 0.233 of the current purchased for light. Then the department uses 0.19 of 0.233, or 0.054 of the amount purchased.

In this way we get the lighting-charge table.

LIGHTING CHARGE TABLE

Factory I Dept.	Percentage	Factory S Dept.	Percentage
1	0.054	11	0.102
2	0.022	12	0.040
3	0.010	13	0.115
4	0.033	14	0.043
5	0.055	15	0.043
6	0.030	16	0.096
7	0.020	17	0.032
8	0.009	18	0.023
		19	0.033
		20	0.009
	0.233		0.536

Electric Power Charges—The two factories do not use power the same number of hours per day and we therefore use the same reasoning as with the light charges and get the following:

HORSEPOWER TABLE

Factory I Dept.	E.Hp.	Factory S Dept.	E.Hp.
1	21	11	.....
2	205	12	15
3	8	13	53
4	165.5	14	17.5
5	28.5	15	3
6	3	16	3
7	10	17	.....
8	5	18	7.5
9	.....	19	28
10	.....	20	5
	446		132

Factory I	446	0.75 rating
Factory S	132	0.225 rating
Power house	15	0.025 rating
Total	593	1.000 rating

We find, by dividing the average use of current purchased for power by the average hours per month, that the factory uses an average of only 156 kw.-hr. per hour, which is a small percent of the rating of the motors in use.

AVERAGE USE OF KILOWATT-HOURS

Factory I	0.75 × 156 =	117 per hour
Factory S	0.225 × 156 =	35 per hour
Power house	0.025 × 156 =	4 per hour
	1.000	156

The use of power covers the following: Factory I, 9 hours per day; Factory S, 15 hours; power house 9 hours.

Then the percentage chargable to the divisions, allowing we pay for 502,204 kw.-hr. per year, is as follows.

Factory I—117 × 9 × 309 = 325,277 kw.-hr. per year = 0.65.

Factory S—35 × 15 × 309 = 165,723 kw.-hr. per year = 0.33.

Power House—4 × 9 × 309 = 11,124 kw.-hr. per year = 0.02.

The amount of current used in the power house for power is chargable there in full.

For the factories we use the same reasoning as in making up the Lighting Charge Table and get the power-charge table.

POWER-CHARGE TABLE

Factory I Dept.	Percentage	Factory S Dept.	Percentage
1	0.037	11	.....
2	0.300	12	0.037
3	0.013	13	0.132
4	0.230	14	0.044
5	0.043	15	0.0076
6	0.005	16	0.0076
7	0.014	17	.....
8	0.008	18	0.019
		19	0.075
		20	0.0078
	0.650		0.3300

Example No. 3 covers a power plant that produces all the steam and electric current required by the works.

During the year this plant produced 206,106,150 lb. of steam costing $69,923, or 34 cents per thousand pounds, and 1,970,970 kilowatt-hours, costing $20,239, or approximately 1½ cents per kilowatt-hour.

Steam-flow meters were used throughout the plant during the year, and by taking readings a month at a time and keeping track of the amount of steam used on each line and the number of hours each was in service, data were secured for the steam-distribution table.

STEAM-DISTRIBUTION TABLE

Department	Percentage
Electrical generation	0.30
Air compressors	0.078
Nickel plating	0.070
Steam hammers	0.017
Steam elevators	0.030
Soda steam processes	0.122
Feed pumps	0.028
Steam heat	0.175
Radiation losses	0.180
	1.000

The steam for electrical generation was charged to the cost per kilowatt-hour at the above production rate. The steam for air compressors was charged out to the departments at the cost in the boiler room. The steam for nickel plating was charged to that department at the boiler-room rate. The steam hammers were charged direct with their quota. The steam elevators were charged direct with their quota, and this cost added to the cost of attendance and the total distributed among the departments served by the elevator. The soda steam processes were charged direct with their quota. The steam for feed pumps entered into the boiler-room costs. The steam-heat cost was figured at the boiler-room rate and this total distributed as in Example One of this article.

Electrical Cost Distribution—The total cost of electrical generation was charged off direct to each department by means of meters placed on each circuit in turn for periods of a month and assuming that each department used for the year at the rate that was shown for a month.

This cannot be done if machines are moved from one department to another or if the volume of production for a given time changes. But these two remained the same during the year.

General Remarks

These examples all together can only serve to point out the direction to a more complete system of maintenance-department accounting. They are not complete for the reason that none of these plants is equipped to carry out the plan in full. Even as they are, the results have been a step forward, and such a system must soon become the rule instead of the exception. Especially is this true of power-plant accounting for the reason that every plant will eventually be rated according to the comprehensiveness of systems that will keep account of the use of natural resources so vital to the country at large.

To make this system complete requires an equipment of recording instruments that will give the following information.

1. Fuel used.
2. Steam produced.
3. Temperature of gases.
4. CO^2 in gases.
5. Temperature of superheat (where it is used).
6. Temperature of steam.
7. Steam pressure (in boiler room).
8. Steam pressure (in engine room).
9. Draft pressures (under and over grates, back pass and stack).
10. Temperature of feed water.
11. Steam used in engine room.
12. Kilowatt-hours produced.
13. Output of any engine-room production such as compressed air, refrigeration, etc.
14. Output of boiler room in steam to any department.
15. Output of engine room in electricity or other production to other department.
16. Temperature of outside atmosphere.
17. Humidity of outside atmosphere.

Instruments to cover the recording of these items are necessary for the compilation of data for power-plant records such as outlined in the article under that head.

In addition, supplementary meters must be installed to make a complete distribution of maintenance costs among the departments of the whole works. These other instruments should cover the recording of amounts of water, gas, air, electricity, steam and fuel oil for departments.

A Refrigeration Problem

By G. Grow

In trouble hunting in refrigerating plants, I often find that the engineers do not understand the method of figuring capacity, horsepower, etc. A problem in refrigeration recently submitted by a refrigerating engineer was as follows: The compressor was a twin-cylinder double-acting machine with cylinders 22 in. in diameter by 48 in. in stroke, the piston rods were 5 in. in diameter, speed 50 r.p.m. The head pressure was 200 lb. gage, while the suction pressure was 20 lb. gage. The brine temperature was 5.89 deg. It was desired to know the refrigerating output of the compressor.

The first essential in the solution of this problem is the determination of the amount of ammonia handled by the compressor per minute. This is obtained by first calculating the actual cylinder displacement per minute. Since the machine is a twin double acting, both cylinder capacities must be figured, not forgetting to deduct for the area of the piston rod on the crank end displacement. Solving for one head-end displacement in cu.ft. we have

$A = Area\ of\ piston \times length\ in\ stroke \times r.p.m.,\ or$

$$A = \frac{3.1416}{4} \times \frac{d}{12} \times \frac{d}{12} \times \frac{L}{12} \times r.p.m.$$

where d is the diameter of piston in inches, L is the stroke, and A is the displacement in cubic feet. In the specific problem d is 22 inches, L 48 inches, and revolutions per minute 50. For the displacement in cubic feet of one head end, we obtain

$$A = \frac{3.1416}{4} \times \frac{22}{12} \times \frac{22}{12} \times \frac{48}{12} \times 50 = 527.5\ cu.ft.$$

For the crank end the piston rod must be taken into consideration. The equation then becomes

$$A_c = \frac{3.1416}{4} \times \left[\frac{d}{12} \times \frac{d}{12} - \left(\frac{d_p}{12} \times \frac{d_p}{12}\right)\right] \times \frac{L}{12} \times r.p.m.,\ \text{or}$$

$$A_c = \frac{3.1416}{4} \times \left[\frac{22}{12} \times \frac{22}{12} - \left(\frac{5}{12} \times \frac{5}{12}\right)\right] \times \frac{48}{12} \times 50 = 500.6$$

when d_p is the diameter of the piston rod. For the two cylinders the displacement is two times the sum of the crank and head end displacement of one cylinder, or

$2 \times (527.5 + 500.6) = 2{,}056$ cu.ft. per minute. The volume occupied by one pound of saturated ammonia gas at 20 lb. gage pressure is 7.99 cu.ft. The theoretical amount of ammonia handled by the compressor is evidently the displacement of 2,056 divided by the volume of one pound of ammonia gas or 257.32 lb.

However, owing to wiredrawing through the suction valves, heating of the vapor by absorption from the hot

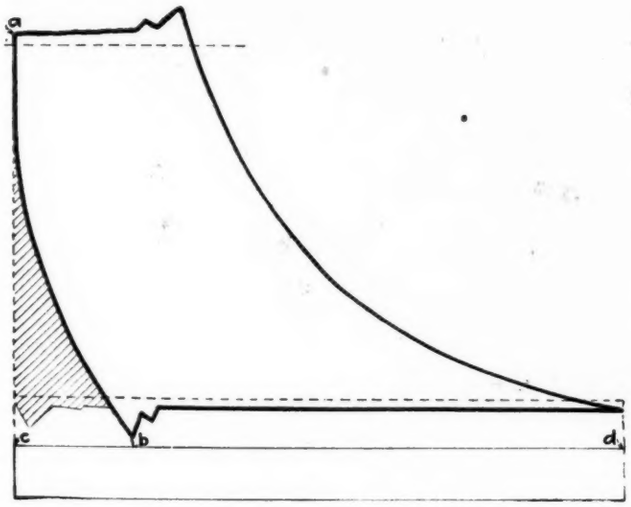


DIAGRAM SHOWING LOSS IN VOLUMETRIC EFFICIENCY

cylinder walls, etc., the actual capacity is much below the theoretical displacement. Allowing a 25 per cent loss, the pounds of ammonia handled by the compressor per minute will be $\frac{75}{100} \times 251.32 = 193$.

It is well here to point out that without an indicator diagram from the compressor all figures as to the actual capacity or the volumetric efficiency are but estimates. If a diagram is obtainable, the actual compressor volume filled with vapor at the suction pressure can be obtained. In the diagram *ab* is the line formed by the re-expansion of the gas trapped in the compression space. Its shape is influenced by the amount of heat absorbed from the walls, etc. Until this clearance gas expands to the suction pressure, no gas can enter from the suction main. The ratio of the distance *bd* to the total cylinder length *cd* is the volumetric efficiency or volume ratio. It may be 80 per cent or 60 per cent, depending on size, design and operating conditions.

The ammonia in the condenser is usually cooled after condensation to around 70 deg. F. In boiling or evaporating in the expansion coils, the liquid ammonia which leaves the receiver at 200 lb. gage pressure (215 lb. absolute) and 70 deg. F. must absorb heat just as water in a boiler must absorb heat to change it into steam. With ammonia as with steam the amount of heat necessary to change from a liquid to a vapor is termed the latent heat (L) of vaporization, and the amount depends upon the pressure within the evaporating vessel. In the case of ammonia the liquid at 200 lb. gage before it passes through the expansion valve possesses an amount of heat depending on the condenser pressure, known as the heat of the liquid (hc). The ammonia liquid in the coils contains a certain amount of heat which may be called hs. It is apparent that, being at a lower pressure, this heat is less than the heat of the liquid ammonia in the condenser. It follows that this difference in the heat of the liquid ($hc - hs$) must be given up by the liquid ammonia. One pound of ammonia, then, is not able to absorb all the heat of vaporization (L) from the brine since part of the heat absorbed comes from the difference in the two heats of the liquid. The amount received from the brine is obviously $Q = L - (hc - hs)$, where L is the latent heat of vaporization at the suction pressure, hc is heat of the liquid at the receiver temperature and hs the heat of the liquid at the suction temperature. These values can all be obtained from the ammonia tables published in *Power*, Jan. 18, 1921.

Substituting the proper values, the expression becomes

$$Q = 564.2 - (120.5 - 49.3) = 493 \text{ } B.t.u. \text{ } per \text{ } minute$$

This is the amount of heat or refrigerating effect produced by 1 lb. of ammonia handled by the compressor. The total amount of ammonia (193 lb.) would produce 193×493, or 95,149 B.t.u. Since one ton of refrigeration is the absorption of 200 B.t.u. per minute, the compression delivers 475 tons of refrigeration. The temperature of the brine has no effect on the refrigeration effect of the machine as here calculated, although owing to heat losses in the pipe, etc., the actual effect may be much less than here indicated.

To determine accurately the actual duty obtained in a refrigeration plant, the volume of brine handled per minute must be measured. This value, when multiplied by the difference in brine outlet and outlet temperature times the specific heat of the brine, will give the actual refrigerating effect. This may be stated in a formula as follows:

$$R = \frac{W(t_i - t_o)S}{200}$$

when R is the refrigerating effect in tons, W is the weight in pounds of brine circulated per minute, t_o is the outlet temperature of the brine, t_i the inlet temperature and S the specific heat of the brine. The specific heat of the brine will depend on its character and proportions.

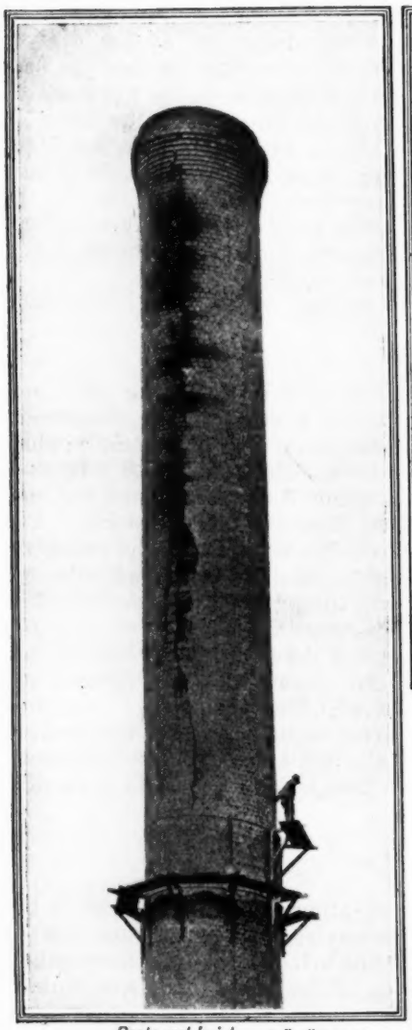
Stop Leaks

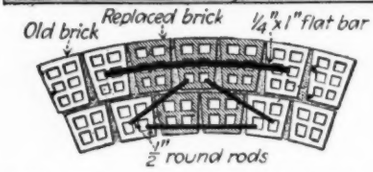
The Rock Island System posts in conspicuous places in the pumping plants and boiler rooms the sign shown below. This sign carries the actual size of holes of various diameters and gives the amount of leakage together with the financial loss incurred. Probably nothing impresses the average person as money, and the column showing the direct money loss should cause many a heretofore unnoticed leak to be repaired.

STOP LEAKS

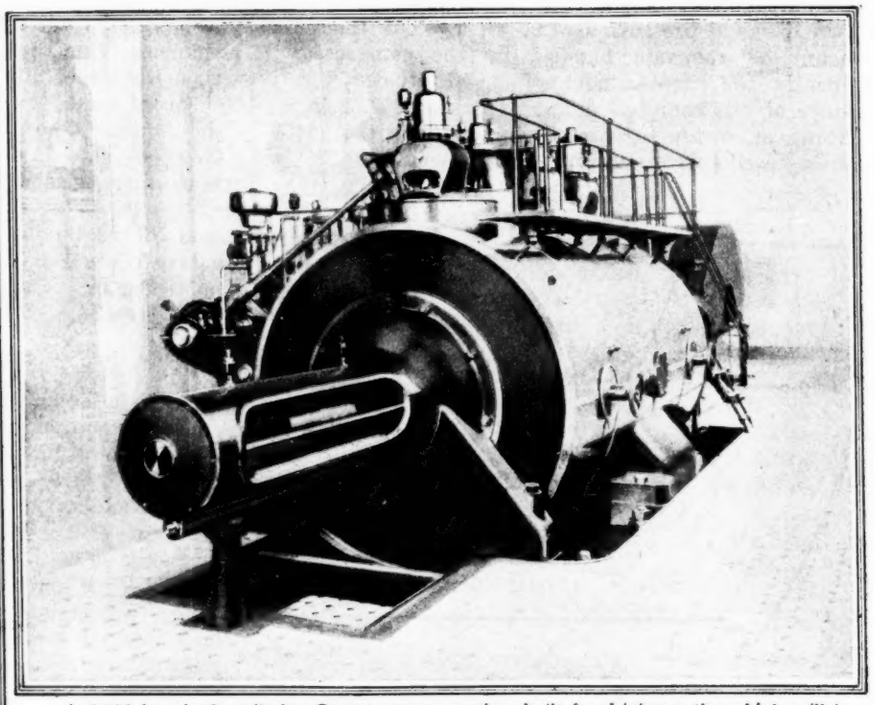
SIZE OF OPENING	AIR		STEAM		WATER	
	NO. OF CU. FT. WASTED PER MO. 100 LB. PRESSURE	TOTAL COST OF WASTE PER MONTH @10¢ PER M CU. FT.	NO. OF POUNDS WASTED PER MO. 100 LB. PRESSURE	TOTAL COST OF WASTE PER MONTH @ 60¢ PER M LB.	NO. OF GALLONS WASTED PER MO. 40 LB. PRESSURE	TOTAL COST OF WASTE PER MONTH @15¢ PER M GALS.
3/8" ●	9,979,200	$997 92	460,000	$276.00	692,400	$108.00
1/4" ●	4,449,600	444.96	203,000	121 80	307,700	48.00
1/8" ●	1,114,560	111.46	50,500	30.30	76,900	12.00
1/16" •	278,640	27.86	12,750	7.65	19,200	3.00
1/32" •	69,552	6.96	3,175	1.91	4,800	0.80

AIR STEAM & WATER COST MONEY
DONT WASTE THEM
SHOVEL LESS COAL

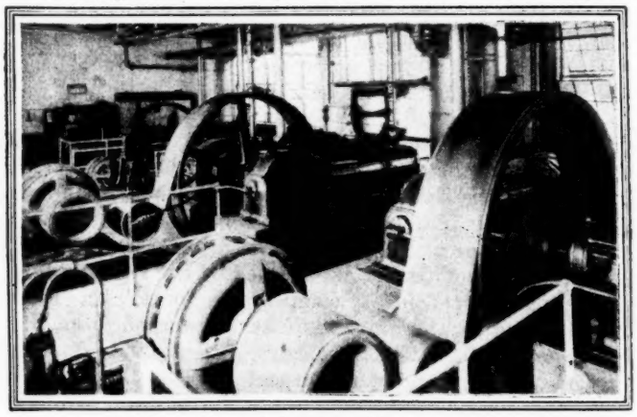




A lightning flash struck the top rim of this unprotected stack and ran down the inside, jumping from rung to rung of a ladder formed by separate iron bars in the brick-work. The break was repaired by inserting new brick, which were tied to the old by steel rods as shown on the left. These rods were placed in every fourth course at first, increasing to every course where the damage was greatest. The height was 150 ft., but only about 75 ft. is shown here. Note how the scaffolding was raised section by section. The work was done by Peter Drolshagen, of Chicago.

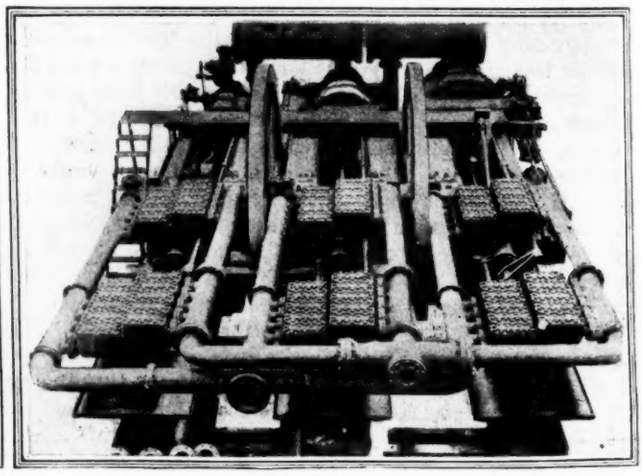


A 6,000-hp. single cylinder German steam engine, built for driving a three-high mill in a Rhenish steel plant. It is of the simple, unaflow type and has a cylinder diameter of 67 in. and a stroke of 55 in. The maximum speed is 130 r.p.m., the steam pressure 118 lb. and the steam temperature 572 deg. F. The makers, Ehrhardt & Sehmer of Saarbrucken, guarantee a maximum steam consumption of 11.47 lb. per hp.-hr. at 110 lb. and 572 deg. F.



A good illustration of the short drive commonly used with air compressors, especially where space is at all limited. An Ingersoll-Rand installation at the plant of the Aluminum Manufactures, Inc.

A National Transit triple-expansion oil pipe line pumping engine.



Two kinds of power—the dangerous and the safe kind. A compressed-air locomotive hauling a load of dynamite at the Hercules Powder Co.'s California plant.

Evolution of the Steam Boiler*

By TERRELL CROFT

STEAM boilers are of ancient origin. They have been used for various services and in many forms since remote times, but prior to the Eighteenth Century none of the devices developed had, as measured by present-day standards, any practical value. However, it is desirable to consider for a moment some of the boilers of the pioneer types so that the reader may be conversant with the evolution that has occurred.

The first boilers were of Greek and Roman origin, so it is believed. They were employed several hundred years prior to the Christian Era and were small affairs used for warming water, heating, and household services. The boiler of Fig. 1, recovered from the ruins of Pompeii, constitutes a typical example. It was of cast bronze, and was evidently of the "internally fired" type. The grate (Fig. 2) comprises sheet-bronze tubes opening and brazed into the water leg of the boiler. From this it is evident that the water-tube principle is an old one.

When in use, the boiler proper was supported on an ornamental tripod which permitted the air required for combustion to enter from beneath. Three gas vents were arranged from the furnace chamber through the water leg to provide an exit for the products of combustion. The actual Pompeiian boiler was embellished with finely wrought ornaments and with miniature sculptures. The first instance of a boiler recorded as doing mechanical work was that used with Hero's engine about 130 B. C., which consisted merely of a hollow sphere, mounted and revolving in trunnions and having extending from it two nozzles with right-angle turns at their ends. Steam from the boiler was admitted to the interior of the sphere through one of the trunnions. This steam, in issuing from the nozzles, caused the sphere to rotate by virtue of the same principle as that on which the impulse turbine operates.

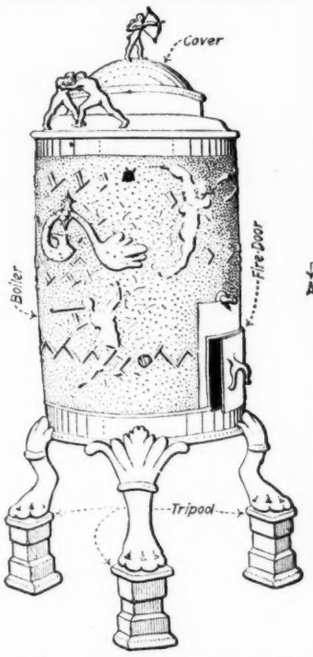


FIG. 1. POMPEIIAN DOMESTIC WATER-HEATING BOILER, 79 A.D.

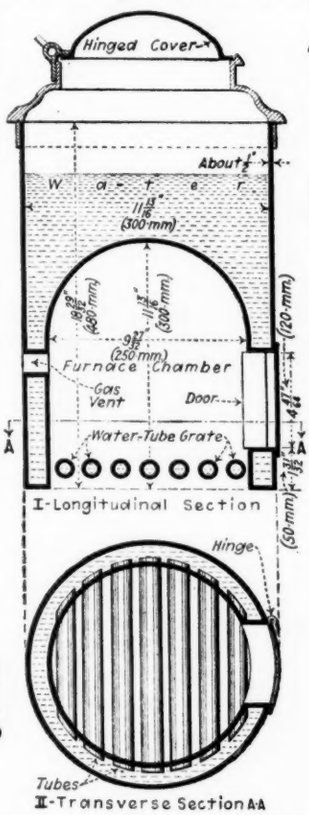


FIG. 2. DETAILS OF THE BRONZE POMPEIIAN BOILER (LEGS NOT SHOWN)

Florence Raivault's "steam bombshell" (Fig. 3) was used by that experimenter in 1605 to determine the disruptive force of steam. The spherical shells consisted of hollow copper castings and were made with walls of varying thickness. Each shell had a single orifice. The experiment consisted in filling a shell with water, plugging the orifice, and applying heat.

Giovanni Branca's boiler was made about the year 1629. Branca was an Italian physicist. His invention consisted of a casting in the shape of a hollow human head and trunk, in the mouth of which was a nozzle. The hollow casting was filled with water and a fire built around it. The steam, which then issued from the nozzle, impinged on a wheel having vanes around its periphery. Thus the wheel was caused to turn, and by means of gears its power was transmitted and caused to perform work.

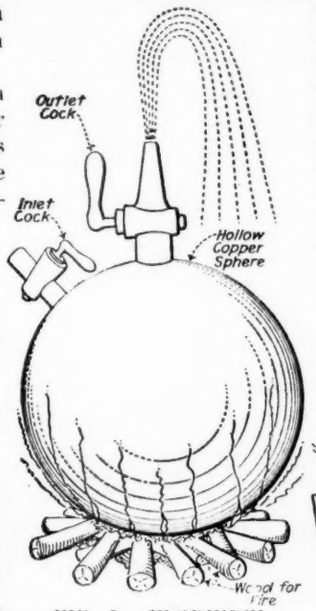


FIG. 3. FLORENCE RAIVAULT'S STEAM BOMBSHELL, 1605

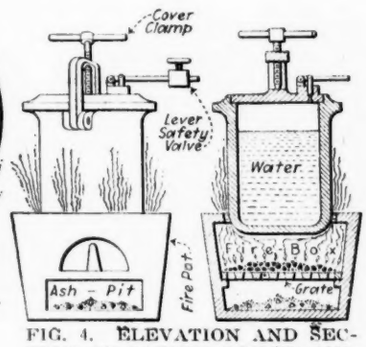


FIG. 4. ELEVATION AND SECTION OF PAPIN'S BOILER AND SAFETY VALVE, 1680

Denis Papin's boiler (Fig. 4) was used in 1680, so it is recorded, as a "digester," or apparatus for converting the bones of cattle into a gelatin-like substance. The process required steam at a very high temperature. To obtain the requisite degree of heat, Papin developed a steam pressure of 1,500 lb. per sq.in. He appears to have been the first to produce steam at a pressure greater than 100 lb. per sq.in. This boiler was fitted with a lever safety valve. It is asserted by some that Papin was the inventor of the safety valve.

Savary's boiler (Fig. 5), so named after its constructor, was made in 1698. This apparatus utilized the phenomena of both condensation and pressure for elevating water. The shell was spherical. This, apparently, is the pioneer example of the application of a specially designed setting and furnace for a steam boiler.

Savary's "improved" boiler (Fig. 6), constructed in 1702, was an evolution from his original invention. In this, the boiler proper was, so it is believed, a hollow cylinder having dished ends.

*All rights reserved. This material constitutes part of the author's forthcoming book, "Steam Boilers."

Dr. Desagalier's spherical boiler (Fig. 7) was built in 1718. In this design the hot gases from the fire were caused to circulate in a spiral flue around a spherical water vessel. This marked an advance in beneath, and thus provided a means of suspension in the setting which permitted the arrangement of an annular combustion chamber around the shell. This boiler was, presumably, braced with some sort of

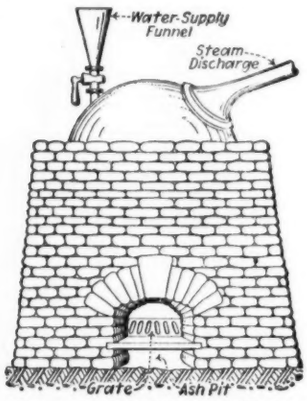


FIG. 5. SAVARY'S SPHERICAL BOILER, 1698

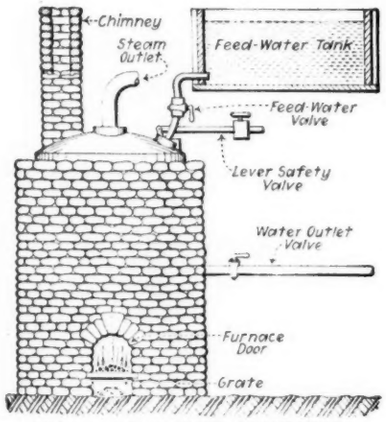


FIG. 6. SAVARY'S IMPROVED BOILER, 1702

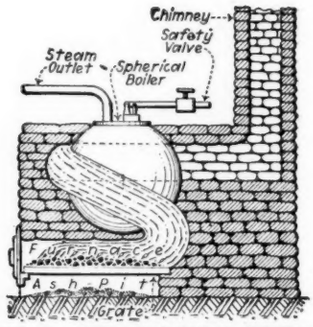


FIG. 7. DESAGALIER'S SPHERICAL BOILER, 1718

furnace construction, inasmuch as there was not, so far as known, any attempt made in the design of the earlier boilers to guide the hot gases through paths where they would be most effective in evaporating the water.

Newcomen's mushroom-shaped boiler, the first real steam generator (Fig. 8), was built in 1705 and was used to generate steam for Newcomen's atmospheric engine. Previous inventors had inclined generally to the spherical form of vessel as affording maximum strength, but as the engine developed by Newcomen was operated with steam at a very low pressure, he was able to depart somewhat from the spherical form. Hence, he designed a boiler that would give a greater proportional area of heating surface and so insure better economy.

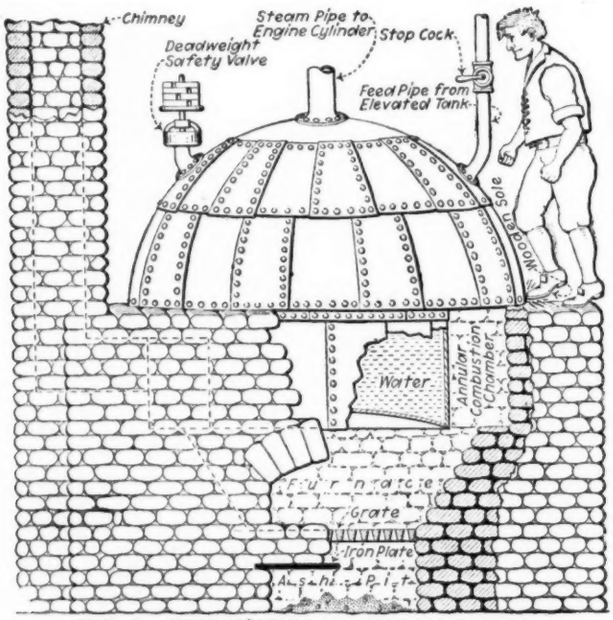


FIG. 8. NEWCOMEN'S MUSHROOM BOILER

The upper half was hemispherical. The lower half was cylindrical with a concave furnace- or crown-sheet. The spherical dome overhung the cylindrical shell diagonal or gusset stays which secured the flat ring- or base-sheet to the dome.

The accessories of these primitive boilers usually included a dead-weight safety valve, but they were often without gages for indicating the water level and steam pressure. The height of the water in the boiler was determined by the sound, hollow or otherwise, as given out by the boiler sheets when struck with a club or kicked with the wooden-soled brogans worn by the attendant. The simmering of the safety valve indicated when the fire was sufficiently hot. The steam outlet was in the crown of the dome. The water was fed in from an elevated tank by gravity. A round manhole, which had its cover fastened on the outside with stud bolts, was provided in the dome.

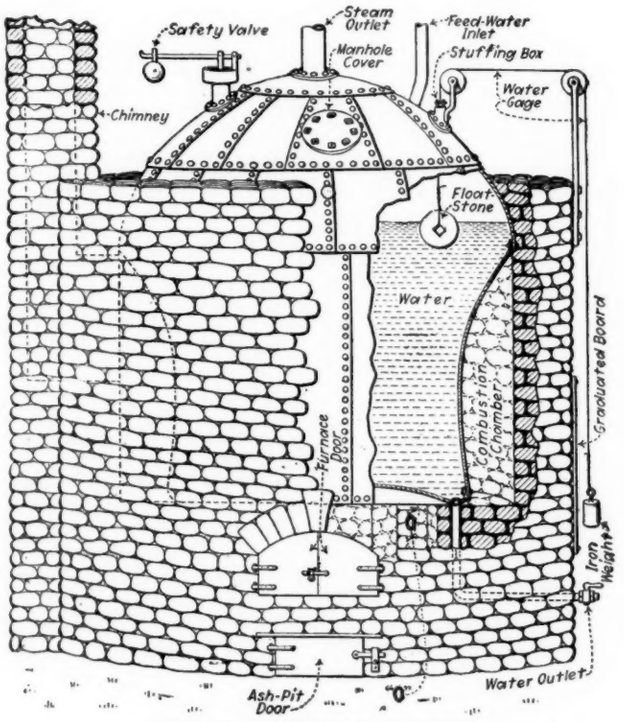


FIG. 9. HAYSTACK BOILER

The "haystack" boiler came into use about the middle of the eighteenth century (Figs. 9 and 10). This was probably introduced by Smeaton and was a modification of the mushroom boiler. It was designed to provide greater strength. This was effected by eliminating the flat ring sheet, which formed the base of the dome, and by approaching throughout more nearly the spherical form. Its setting was similar to that of the mushroom boiler with the exception that the furnace wall was drawn in near the bottom, to permit the flange of the crown sheet to sustain the entire weight. Access from the furnace to the annular combustion chamber was provided by three or four openings (*O*, Fig. 9) in the masonry. These "haystack" boilers, so it is believed, were sometimes braced by tying the dome sheet to the furnace sheet with through tension-rod stays, but were generally constructed without stays. Many boilers of this type continued in use in England during the first quarter of the last century.

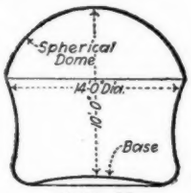


FIG. 10. DIAGRAMMATIC SECTIONAL ELEVATION OF HAYSTACK BOILER

The equipment of the haystack boiler (Fig. 9) shows improvements over that of its predecessor (Fig. 8), as it includes a ball-and-lever safety valve and a "float-stone" for showing the water level. A "float-stone" consisted usually of a worn-out grindstone hanging on a copper wire on the inside of the boiler, which passed out through a stuffing box and ran over two pulleys to an iron weight. The stone rose and fell with the water level and the stage of water was indicated by the position of the weight in relation to graduations on a board in front of which it traveled up and down. A water-outlet pipe, with a stop cock was also provided.

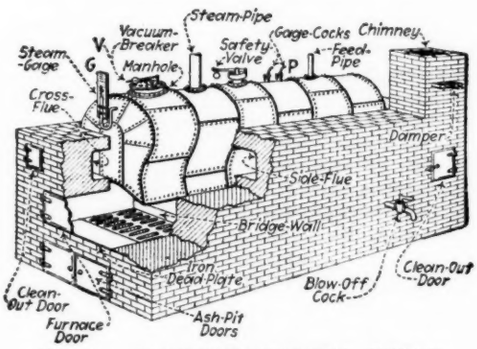


FIG. 11. WATT'S WAGON-TOP BOILER

Watt's "wagon boiler" was the first radical departure from the spherical form. This (Fig. 11) was designed by James Watt in about 1765. The upper half was semi-cylindrical, and the lower box-shape with concave sides. The bottom was concave and the ends flat. The masonry was closed in at the upper and lower edges of the concave side sheets, so as to form flues along the sides. The two side flues were joined at the front end by a duct which was hollowed out in the masonry. They were separated at the back by a baffle wall that divided the chimney from the back connection. The products of combustion thus swept along the bottom sheet to the back end (about as shown in Fig. 12 for the egg-end boiler), returned through a side flue to the front end, crossed to the opposite side flue and passed thence to the chimney. It is probable that these

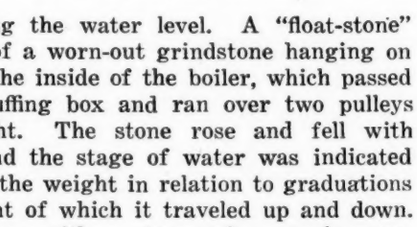


FIG. 12. WAGON-WHEEL DRAFT CIRCUIT OF THE EGG-END BOILER

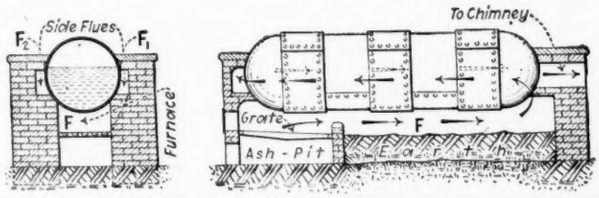


FIG. 13. THE EGG-END OR CYLINDER BOILER. ABOUT 1790

"wagon" boilers were sometimes braced by tying the side sheets together with stay-rods, but they were generally without braces of any kind. None of them could handle safely a pressure in excess of about 10 lb. per square inch.

The accessories of Watt's boilers included some appliances that were absent in the designs devised by his predecessors or that were used by them in cruder forms. Notable among Watt's fittings are the steam gage, the water-gage cocks and pipes and the vacuum breaker. The steam gage *G* was merely a brass U-tube screwed into the front end of the boiler shell and containing a quantity of mercury. A wooden float, which was carried on the surface of and rose and fell with the mercury column in the outer leg of the U-tube, supported a slender arrow. Thereby the pressure was indicated on a graduated scale which was attached to the tube. The water-gage pipes *P* extended down into the boiler. One of them terminated in the steam space an inch or two above the normal water level, and the lower end of the other extended into the water space to a depth of about two inches below it. The vacuum breaker *V* was a valve which, opening inward, was designed to prevent collapse of the structure by the external pressure of the atmosphere when, after being in service, the boiler was permitted to cool down.

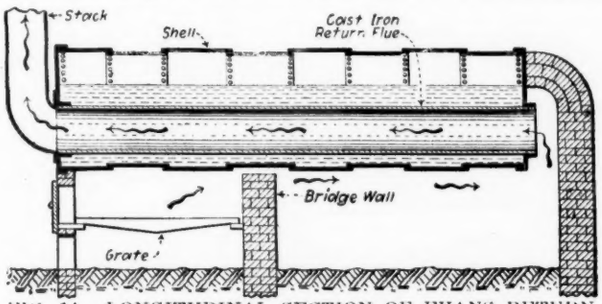


FIG. 14. LONGITUDINAL SECTION OF EVANS RETURN-FLUE BOILER, 1800

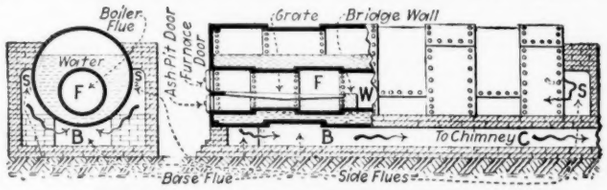


FIG. 15. TRANSVERSE AND LONGITUDINAL SECTIONS OF THE CORNISH BOILER. ABOUT 1800

The "egg-end" or cylindrical boiler was the next development. With the extended use of steam power

during the closing years of the eighteenth century there came a corresponding increase in the steam pressure required for the newer applications. Coincidently, there developed a demand for stronger steam-generating apparatus. About this time the oddly shaped shell of the wagon-top boiler lost its vogue and was superseded by a shell of cylindrical form. Furthermore, the flat wrought-iron head plates of the wagon boiler were displaced by thick semi-cylindrical cast-iron heads, which tended to provide a boiler of somewhat oval or egg form (Fig. 13). However, in its settings and accessories the egg-end boiler retained all the essential characteristics of its immediate predecessor, the wagon-top. These inherited features included the arrangement of the side and cross-flue (Fig. 12) for creating a "wheel draft," as the circuit of the furnace gases around the boiler was termed. The idea of putting the return flue inside the shell of the boiler instead of running it around outside was first conceived by an American engineer, Oliver Evans, so it is believed. His invention (Fig. 14) was the direct forerunner of all subsequent

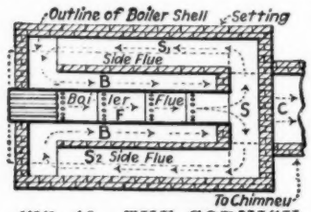


FIG. 16. THE CORNISH BOILER SPLIT-DRAFT CIRCUIT

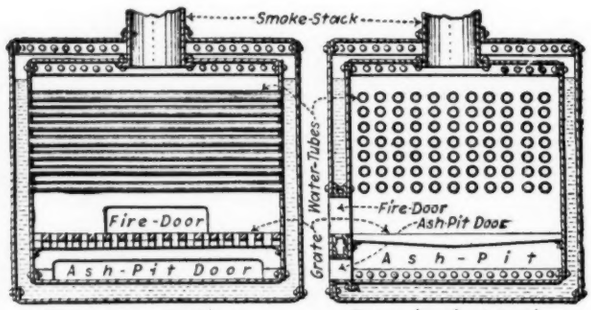


FIG. 17. LONGITUDINAL AND TRANSVERSE SECTIONS OF BARLOW'S HORIZONTAL WATER-TUBE BOILER, 1793

designs of horizontal return-tubular and flue boilers. Some of these boilers made in about the year 1800 had cast-iron shells and wrought-iron flues, the diameter of the flue being usually about half the shell diameter.

The Cornish boiler (Figs. 15 and 16) designed by Richard Trevithick, an English engineer connected with

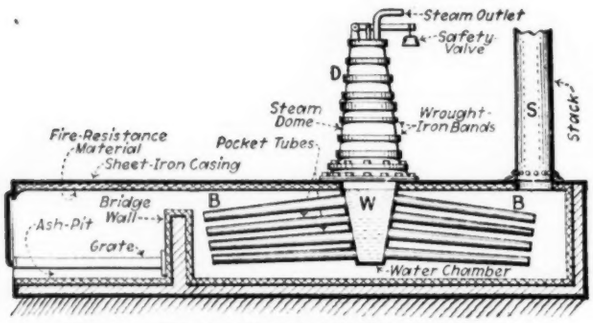


FIG. 18. STEVENS' PORCUPINE BOILER, 1804

the Cornish mining industry, was the result of a plan to improve boiler economy. Trevithick proposed to locate the furnace inside the flue. The original Cornish boiler, thus invented by Trevithick, may be regarded as the forerunner of all internally fired boilers of subsequent types. The boiler was built with a single flue sufficiently large to hold a furnace having a grate area proportioned properly to the available heating surface. The furnace was made by mounting the grate bars on bearer bars, which were secured crosswise to the flue at the front and rear ends of the furnace. A bridge wall *W*, to hold the fire on the grate and to form an ashpit, was erected at the rear of the furnace. The

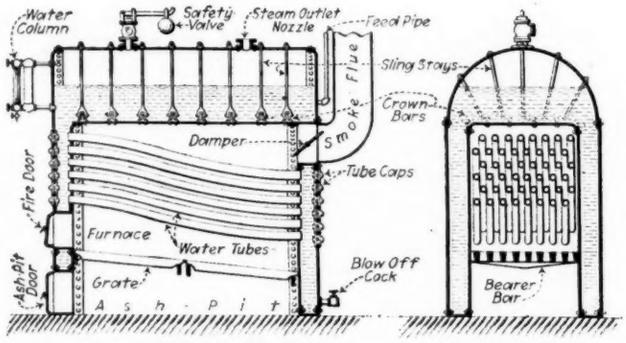


FIG. 19. WILCOX'S BOILER WITH INCLINED WATER TUBES, 1856

current of the furnace gases passing out of the flue at the rear end *S*, divided and returned through side flues S_1 and S_2 to the front end. Thence they flowed through a single flue *B* along the bottom of the shell and into the smoke conduit *C* at the rear.

The first water-tube boiler that embodied the fundamental structural details of modern boilers of this class was the invention of James Barlow (Fig. 17) about the year 1793. This boiler had front and rear water legs. It consisted of a cubical wrought-iron box having within it a smaller box-like structure. A number of straight tubes extended across from side to side within the smaller box. The preponderance of unstayed flat surface, the exposed top sheet of the firebox, and the restricted water circulation, were all obvious disadvantages of this design, although it was, perhaps, safe for the pressure commonly employed in its time, 3 to 7 lb. per square inch.

A boiler of the porcupine type was devised by James Cox Stevens (Fig. 18) in 1804. In it a number of blind or pocket tubes were secured in the inclined front

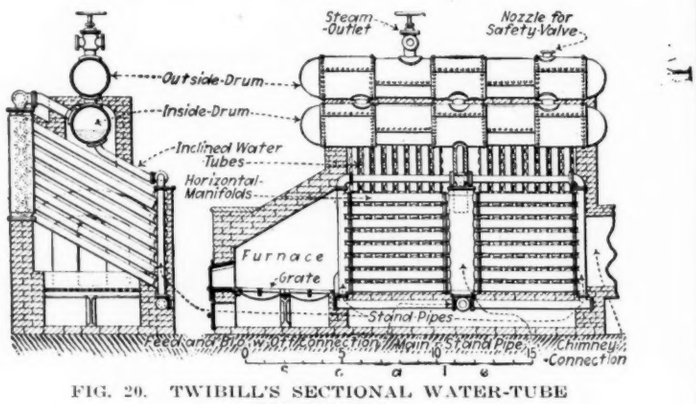


FIG. 20. TWIBILL'S SECTIONAL WATER-TUBE BOILER, 1865

and rear faces of a cast-iron water chamber *W* having a rectangular cross-section. The products of combustion, in passing to the chimney *S*, circulated among the tubes *B*. The water chamber served as a baffle wall,

to deflect downward the current of gases through the front bank of tubes and up through the rear bank. A tall steeple-shaped steam dome, made of wrought-iron plates and strengthened with wrought-iron bands shrunk on outside, was bolted to the top of the water chamber. The boiler was built for a working pressure of 50 lb. per square inch and marked a definite advance in the design of high-steam-pressure generating apparatus. Its most serious defect appears to have been the impos-

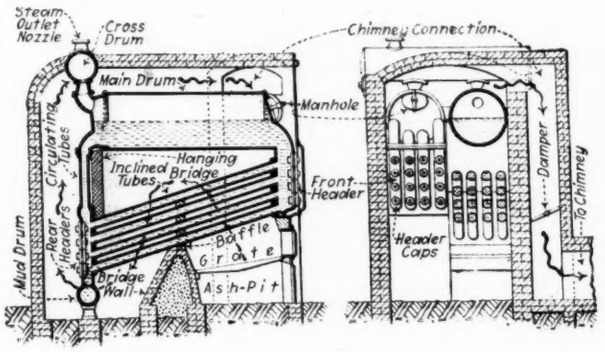


FIG. 21. EARLY FORM OF BABCOCK & WILCOX BOILER, 1870

sibility of adequate water circulation in the tubes. This resulted in the tube ends filling with sediment and burning off.

Wilcox's water-tube boiler (Fig. 19) was invented in 1856. This incorporated the general features of Barlow's (Fig. 17) early attempt, but was vastly superior both in design and operation. The water leg extended entirely around the firebox, and a nest of water tubes, which had a downward inclination, traversed the firebox from front to rear. The crown sheet of the firebox was braced with sling stays which were secured to the semi-cylindrical top sheet. The inner and outer sheets of the water leg were tied together with stay-bolts. From this elementary design were evolved the various classes of modern water-tube boilers which have inclined tubes that connect front and rear headers or legs.

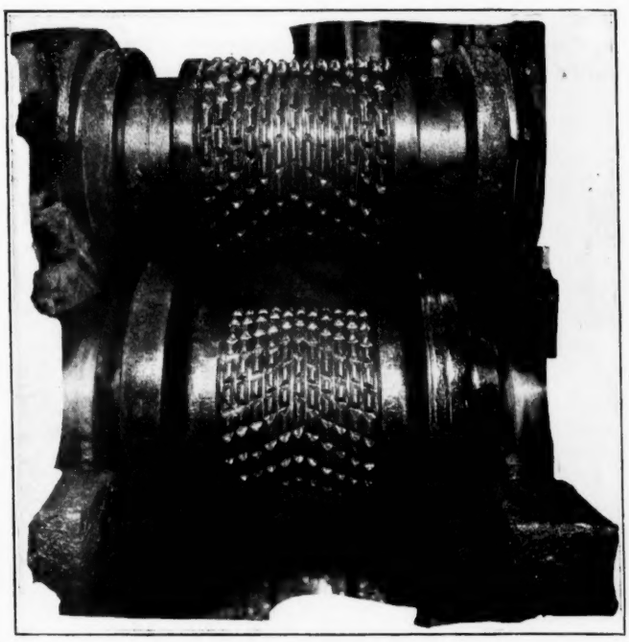
The first sectional boiler having inclined water tubes was made by George Twibill (Fig. 20) in 1865. A nest of inclined wrought-iron tubes traversed the combustion chamber from side to side. The separate fore-and-aft rows of tubes connected, at each side, to horizontal manifolds or headers. These headers were attached, front and rear, to standpipes which carried the steam to two superimposed drums above. One drum was inside, the other outside the masonry. The water of entrainment was collected in the lower drum and passed thence to the lower set of manifolds.

The Babcock & Wilcox sectional water-tube boiler of early form, as shown in Fig. 21, was built about 1870. In it were represented the essential constructional principles which were developed and refined in the later designs. The tubes were of wrought iron, the vertical header sections of cast iron, and the two were joined together, in the foundry, by laying the tubes in the mold and casting on the headers. A vertical baffle, which was erected midway, caused the gases of combustion to make two passes through the nest of tubes. The external wall of the setting was built to form a connection to the chimney.

Spellerized Steel Piping

Doubtless many readers of *Power* have wondered what spellerized pipe is and how it differs from ordinary steel pipe. Spellerizing is a process employed by the National Tube Co. and consists of passing the heated bloom, which is the metal produced from rolling ingots in a blooming mill, through rolls and reducing it to the proper dimensions for the finished product. The blooming-mill rolls are smooth on the face, but the spellerizing rolls have regularly shaped projections on their working surface, as shown in the illustration. After coming from the spellerizing rolls, the bloom, while still hot, is subjected to the action of smooth-faced rolls, and the operation is repeated, whereby the surface of the metal is worked so as to produce a uniformly dense texture. This process is applicable to the smallest sizes of pipe, say 4 in. and under, although it is possible in special cases to spellerize pipe a few inches larger. The metal, when finally spellerized, is called skelp, from which the pipe is formed after the edges have been scarfed, for lap-weld pipe, and slightly beveled for butt-weld pipe.

Using understandable terms, the process of spellerizing metal may be considered analogous to the kneading of dough from which bread is made. Dough is kneaded to produce a smooth, uniform texture, to facilitate the



A SET OF SPELLERIZING ROLLS

escape of confined gases which would form airholes and other irregularities in substance and on the surface and to make an even grain and smooth, fine surface. Much the same results are obtained by spellerizing the steel bloom. A uniformly dense texture supplementing the natural uniformity of the metal itself reduces the tendency to galvanic action, which has been found to be the origin of corrosion. Piping with any noticeable tendency to pit is eaten through in spots comparatively quickly, thus terminating the effective life of the pipe. In pipe treated by the spellerizing process there is said to be a marked decrease in the tendency to pit, corrosion proceeding comparatively slowly and uniformly.

Improved Automatic Boiler-Room Coal Scale

Automatic coal scales for boiler-house use, like any other class of machinery, are susceptible of improvement. River coal, reworked culm and wet slack are now frequently fed to stokers and may cause trouble by hanging up. The Richardson Scale Co., Passaic, N. J., has recently designed a coal scale (Fig. 1) that will feed positively under the worst conditions of daily use. This is accomplished by the adoption of a conveyor feed of heavy rubber belting with canvas interwoven, which is the principal feature of the feeding device. It is easily replaced. A simple take-up is provided.

The belt starts when the weigh hopper is ready to receive coal and stops when it has taken in the standard charge of 200 lb. Fig. 2 shows the discharge of coal from the belt into the scale hopper. A square-jawed clutch running in a grease bath determines when the starting and stopping take place, being itself controlled by levers actuated by the beam, but being free from restraint of the beam while it performs its task of balancing.

Less than ½ hp. is required to drive the feed belt. Direct-motor drive and belt drive from a lineshaft are both standard. In one case the motor is omitted, in the other the pulley.

The speed is reduced by two sets of spur gears (and one worm reduction when motor drive is used), located in a cast-iron box which holds the grease bath.

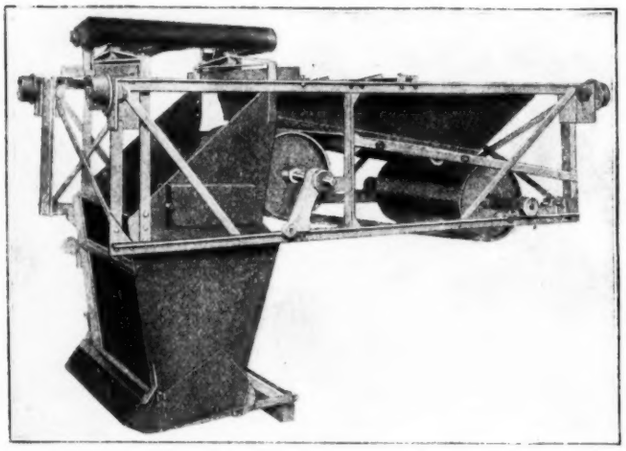


FIG. 1. SIDE VIEW OF IMPROVED AUTOMATIC COAL SCALE

Lubrication once a month is said by the manufacturer to be ample, inasmuch as all the other bearings are of the oilless type or are suitably provided with grease cups.

Corrosion is eliminated, as only copper rivets are used where the coal comes in contact with the walls, and the skirt plates, hopper walls and door plates are made of a fibrous, acid-proof, abrasion-resisting material.

Because the conveyor belt travels slightly uphill, headroom is reduced. A 45-deg. spout can be made steeper by inserting a scale in it.

Suitable inclosing aprons and walls retain the dust and prevent small particles of coal from falling to the firing aisle.

Many features of the devices used with former designs of coal scales have been retained on the new machine. The sealed continuous six-figured mechanical register is the same, and the interlocking device which prevents coal from running through the scale unweighed and unregistered has been simplified and applied also.

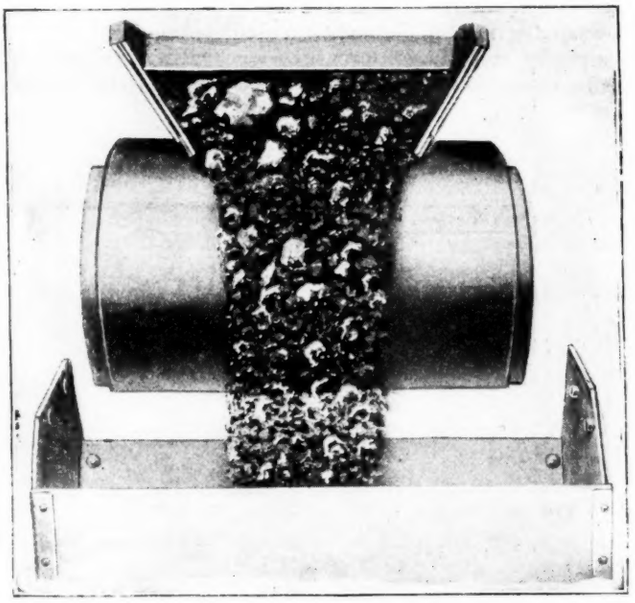


FIG. 2. COAL DISCHARGING FROM CONVEYOR BELT INTO SCALE HOPPER

The beam has but four pivots. Instead of a weight box with loose weights, there is a single poise weighing 50 lb. The beam ratio is 4 to 1. There are two machined seats for the poise—one for zero balance and one for full load balance.

Physical Properties of Materials

During the last few years the Bureau of Standards has received numerous requests for information regarding the physical properties of materials, principally ferrous and non-ferrous metals and alloys. Some time ago the compilation of most of the available data on this subject was undertaken. The tables that were compiled as a result of this work were issued to a limited number of Government establishments in mimeographed form. As they seemed to fill a very real need, it was deemed advisable to issue them in the form of a Bureau publication, and Circular No. 101 is the outcome of this work.

The circular aims to present in readily accessible form the best available data on the strength and related properties of materials. Among those treated are iron, carbon steel, alloy steels, wire and wire rope, semi-steel, aluminum, copper, miscellaneous metals and other alloys, rope, rubber, leather and wood. The tensile strength, proportional limit, percentage elongation in two inches, percentage reduction of area, Brinell and scleroscope hardness corresponding to a certain composition, density and method of preparation are shown in most cases for the metals and alloys. In addition, figures are given in many instances for the compressive and shearing strengths, moduli of rupture and Erichsen values. The circular also includes definitions of the properties treated and references to sources.

EDITORIALS

It is Time To Look Ahead

FAILURE on the part of the public utilities and other large consumers of coal, who have definite knowledge as to their needs, to make contracts for their coal supply is alarming officials in Washington. It is understood that the Interstate Commerce Commission has under consideration the issuance of a warning reiterating the position taken by the Commission that no small part of the responsibility for a general shortage of coal rests with those who fail to make contracts when the cars are available and the mines are able to fill the orders.

Dr George Otis Smith Director of the United States Geological Survey, makes the following statement as to the general situation being brought about by the very low rate of bituminous-coal production:

> The consuming public must feel its part of the responsibility in the problem of an adequate coal supply. The coal user large and small, is too much like the Arkansas man who failed to repair his roof in good weather. Today there is a supply of both coal and cars available, but the consumer seems to prefer to take his chances when the demand will be great He hopes for lower prices and thus delays the contracts. This procedure is not helping to put coal production and distribution on a twelve-month basis. A seasonal demand is injurious to the coal operator to the coal miner and to the railroads, while in the end the buyer of coal has to pay more than he would had he co-operated in helping to stabilize coal production and movement.

Let us avoid next fall and winter a repetition of the conditions experienced the past two years.

Polarity of Transformers

ALTHOUGH much has been done in the way of standardizing transformer polarity, there still exists much confusion as to the use of the term polarity. Polarity as applied to a source of direct current has a definite meaning, one terminal having a fixed positive polarity and the other a fixed negative sign, and when once established remains so, the positive terminal being at a higher potential than the negative. But with alternating-current equipment the polarity is constantly changing, and in a transformer the relative polarity between the primary and secondary terminals will depend upon how the leads are brought to the outside of the tank and the arrangement of the windings on the core. Adopting various practices by the manufacturers with regard to these relations in the earlier development of the transformer has been the cause of much complication and discussion and many mistakes in making connections in one of the simplest of electrical devices.

There is probably no more reason to expect that transformers should be grouped in parallel or in star or delta connections without thoroughly testing for correct polarity than when paralleling any other electrical power equipment. However, with transformers they are frequently, especially in the smaller sizes, installed and put into service by workmen who have a very limited knowledge of the equipment they are handling. Consequently, in many cases they are put into service more by rule of thumb than by any test to determine any inconsistencies that may have developed in manufacture, repairs or installation. Under such conditions any confusion as to the method of bringing out the primary and secondary leads will result in mistakes.

Adopting a system of marking the leads of transformers has done much to rectify the confusion regarding their polarity as discussed by J B. Gibbs in an article on "Polarity of Single-Phase Transformers," in this issue. However, this does not eliminate the complication of connections that results from connecting two or more transformers of different polarity into a group. Therefore, if the manufacturers would agree upon some standard polarity for all new designs, at some future day we should arrive at a time when the polarity of all transformers would be standardized, even if this period is somewhat remote. In the meantime the system of marking would have served a good purpose.

Advances in American Diesel-Engine Design

PROBABLY the most striking advance made of late years in Diesel-engine design has been the increase in engine horsepower. In the United States the tendency until two or three years ago was to hold the cylinder size below one hundred and fifty horsepower. The manufacturers were content to build and market engines of five hundred horsepower and under In fact, the average engine rating, considering all the Diesels manufactured in this country, since 1898, is slightly under two hundred and seventy-five horsepower. Since the Diesel demand came from small central-stations, oil-pipe line and like plants, low-powered engines were logical. The oil-pipe lines absorbed more than thirty per cent of the engine output; these stations must have duplicate units, and five hundred horsepower is about the maximum size that can be used. The small central-stations, where efficient steam operation was impossible, required well under five hundred horsepower. The engine builders largely influenced this demand for only small engines, for it is only of recent date that the one time perplexing problems of crankshaf failure and cylinder-head fracture have been solved

While the European builders have been turning out engines of large size for several years, the American manufacturer has recently shown a marked tendency toward the designing of large units; at the present time the maximum output of any American engine is twenty-seven hundred brake-horsepower. While this Bethlehem engine is the largest in point of delivered horsepower, it has six cylinders and on the basis of individual cylinder capacity is now overshadowed by the Nordberg Diesel described in this issue of *Power*. The latter engine is of the two-stroke-cycle type and

has four cylinders of five hundred brake-horsepower each. The design is such that two more cylinders can be conveniently added, giving a three-thousand horsepower unit.

There is every reason for this increase in engine horsepower. Many plants of three thousand to five thousand horsepower now operating with steam in unfavorable localities have found the power costs mounting to alarming figures. While fuel and labor costs may show some decrease in the future, they will never return to the pre-war level. It is impossible to consider replacing such equipment by ten or a dozen small Diesels. The maintenance costs, which are more or less in direct ratio to the number of vital working parts, would be prohibitive, while the labor would also be high since it is in ratio with the number of units installed The production of these larger Diesels enables plants above two thousand horsepower to install oil engines. The cost per horsepower of the large units is undoubtedly well under the costs of small engines. The repair charge should be less, since better workmanship is possible and the character of operators can be higher

One might also here make mention of the activity in the building of Diesels of almost miniature capacities. Several concerns are manufacturing engines under one hundred horsepower. One builder has devoted his entire attention to these small units and has sold a large number of engines of seventy-five horsepower and under This can be taken as indicative of the progress made toward the simplification of the Diesel so that it can be handled by the average mechanic after some shop instruction

The drift toward the two-stroke-cycle design is very prominent. The early two-stroke-cycle engines cannot be said to have been successes. Many builders found it advantageous to adhere to the four-stroke-cycle type. The early mistakes of design have been overcome and the many points of merit of the two-stroke-cycle design, especially for large engines, have forced a readoption of this principle. At present several American firms are building two-stroke-cycle engines, of both large and small capacities. It is interesting to note that of the three hundred and seventy thousand Diesel horsepower built in the United States since 1898, sixty thousand horsepower are of the two-cycle type. In the last four years approximately fifty thousand horsepower of two-stroke-cycle engines have been built in America. Even these engines here termed large are small when compared with the two twelve-thousand-horsepower engines which have been built by German firms. Such capacities are by no means beyond the scope of American builders and if built here would enable large power plants to be Diesel-engined.

When Is It Worth While?

IT IS always a serious problem of management to determine when the substitution of new methods or new equipment for old is justified. It is a well-recognized principle that the margin of operating advantage must be wide enough in favor of the new equipment to justify the risk of a new system as well as the investment of new money. Recently, in Virginia, one small power plant, admittedly very inefficient—in fact, almost worn out—was compelled to continue generation of power on the present wasteful basis despite the fact that a high-tension line passed close to the plant. It was apparent that the cost of energy from this high-tension system would be much less than the cost as generated in the steam plant; but there was one serious objection to making the change—the management could not raise the several thousand dollars required for the new transforming station that would be needed The superpower survey engineers have recognized a similar limitation in interconnection of systems and railway electrification. They have figured that on any portion of the line burning less than a thousand tons of coal per mile per year, it is not feasible to electrify. The cost of investment would be too great, even assuming large economy in fuel for the energy needed.

In industrial power plants where new types of equipment are under consideration, these same problems are met and the same principles apply. The engineer, before he goes to the management with a recommendation for new boilers, new engines or other equipment of increased efficiency, must sit down and carefully figure the capital charges involved. Money costs money, just as truly as does coal, labor or any of the power-plant supplies. The cost of new money must, therefore, be figured in the recommendation for improvements, and the engineer must not forget a charge which can be set aside to amortize and retire the investment in the present equipment which is to be superseded. It is the cost over a period of years for all these items which one must not fail to take into account.

Previous to 1914 financing on a large scale was done in millions, and a million-dollar project was considered to be of some moment. But the war taught us to think in billions, and we are apparently going to continue to apply the big figure in finance. It is a common occurrence to read that a certain state will require one or two billions of dollars within the next ten or fifteen years to carry out its power-development projects. In a report recently presented by James R. Nourse, director of research for the Bureau of Economics, Sacramento, Cal., it was pointed out that the State of California will require one billion dollars within the next ten to fifteen years for power development The Railroad Commission of that state has reported that over two billion will ultimately be required by the state for water-power development alone. These figures applying to a state that represents only about one twenty-fifth of the population of the country gives some conception of the magnitude of the finances required for future power requirements of this country.

It is reported that in the vicinity of Paris (France) there is no period on record of more than sixty hours actually without wind, and that for at least two hundred and forty-five days in the year the wind blows at the rate of nine miles an hour or more. Under these conditions the use of wind turbines becomes quite feasible for the operation of irrigation pumps, electric furnaces, small shops, lighthouses and country lighting plants.

The man who sent a boy to the hardware store for a "left-handed monkey wrench" wasn't so far off after all, if you consider the threads on the adjusting screw Get it?

CORRESPONDENCE

Temperature Rating of Motors

The article by Mr. Phillips in the Jan. 11 issue of *Power* raises the question as to the advisability of adopting the 50-deg. rise rating for electric motors and sets forth in a clear manner some of the factors to be considered. A little further discussion may be in order.

A change from a 40-deg. to a 50-deg. rating basis involves in a large measure, the marking up of ratings of existing motor frames. This will naturally tend toward the use of smaller frames for given purposes, at least temporarily. The question then arises, although the windings may or may not withstand the increased temperature, will the mechanical members withstand the increased duty? In some service, yes; but for the more severe duty the present 40-deg. general service motor is none too strong. It would, therefore, be necessary for such duty, to discount the ratings for mechanical reasons. If general-service motors continue to be cheapened, the solution may lie in two distinct lines of motors; namely, the competitive general-service motor and a more liberal and sturdy motor for the heavier class of duty. This may be a desirable condition. From the viewpoint of uniformity and duplication it appears undesirable.

It is sometimes asserted that the adoption of the 50-deg. rating for induction motors will alleviate power-factor troubles, the inference being that drives are now too generally overmotored. It is true that induction motors do operate at fractional loads to a considerable extent, but this is primarily due to the fact that the load demand of the driven machine is subject to variation dependent upon the duty. For instance, a wood planer may be used on wide planking one day and narrower stock the next, or the quality of the wood may differ. The motor must be able to handle the most severe condition. The rest of the time it will operate at lesser loads and lower power factor. A definite torque and a definite horsepower load exist at the driven shaft, regardless of the motor name-plate. The variation in load will not be changed. Whether the motor is selected for average duty with an overload margin to care for the unusual condition, or whether a maximum rated motor is selected on the basis of maximum duty, the variable-load condition remains and the power factor is affected little, if any.

The point was clearly shown by Mr. Phillips that the 50-deg. motor is "maximum rated" and that there is no margin of safety. The load demand imposed by machinery cannot be predetermined to a highly accurate degree in all cases. Even where it might be determined accurately, this is not always done. Motor loads involve a number of variables. It is more often possible to determine the average condition than to determine the maximum condition. Motors are selected by persons of varied degrees of knowledge and experience. In most branches of engineering, even the most exact, we are taught that it is wise to allow a liberal factor of safety. Why should it be policy, in motor selection, a relatively inexact branch, where the loading is largely beyond observation and control, to abolish the safety margin altogether?

A double standard of rating is undesirable. It tends away from standardization and uniformity. It leads to confusion and makes comparisons difficult. The 50-deg. rating is acceptable only if universally adopted.

Changes in designs and practice are necessary to development. They are, nevertheless, objectionable, and are justifiable only when fully warranted. In the case of motor selection a change in rating will render obsolete or questionable a quantity of experience and published data and formulas as to motor sizes required by machinery. It will create a degree of confusion until new practices are established. Being in the nature of a change, it is, per se, on the defensive. Is there sufficient benefit to be gained to warrant the change? From the user's point of view, the writer believes there is not.

Chicago, Ill. GORDON FOX.

Oil in the Refrigerating System

I agree with Mr. Cunningham's article in the issue of March 1, page 359, in which he states that oil is heavier than liquid ammonia.

I have charge of a small refrigerating plant and in draining the vertical oil separator into the crankcase the oil comes first, then the liquid ammonia. Also, when disconnecting an empty ammonia drum after charging the system, I observed a small quantity of oil dripping from the charging line. The liquid receiver is vertical and at the beginning of the charging period the liquid was at half-glass and did not show any oil on top, consequently the oil which appeared must have come from the bottom of the receiver.

As conclusive proof of this the specific gravity of liquid ammonia is 0.6234 at 0 deg. F., and the oil I am using is 0.91 at 25 deg. F., and at 0 deg. the specific gravity would still be higher. We can infer from these figures that liquid ammonia will float on oil.

Probably in the near future refrigerating-machinery manufacturers will provide a drain cock at the lowest point of the liquid receiver, so that the oil can be drained off, as it is from this point that the oil enters the expansion coils, where the harm is done.

Bloomfield, N. J. P. E. LOBBAN.

Two Pump-Stopping Devices

One of the objectionable features of operation of a steam pump used for filling house tanks, which are generally located on the roof of the building, is that the tank, on becoming full and unobserved by the engineer, will overflow and water will go to waste. The two illustrations herewith show devices that I have made

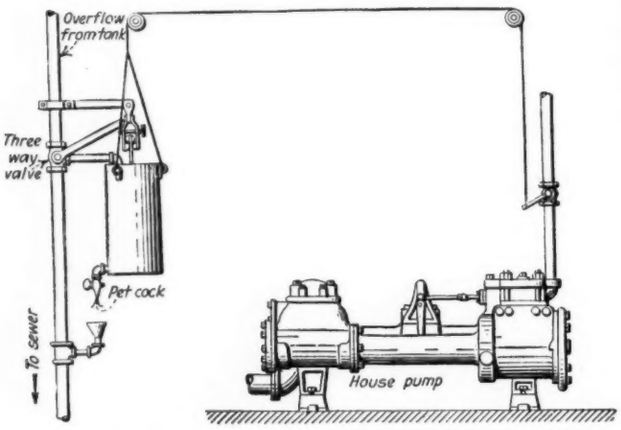


FIG. 1. AUTOMATIC DEVICE APPLIED TO HOUSE PUMP

and have had in successful operation and that so operate that when the tank becomes full to the overflow, the pump is automatically stopped.

Refering to Fig. 1, the steam pipe is fitted with a valve of the quick opening and closing type, the stem of which is fitted with a lever. Attached to the overflow pipe is an arm that supports two springs. Just below the arm is a three-way valve, the side outlet of which discharges into a can that is suspended by the tension of the springs. A cord runs over suitable pulleys to the valve lever of the pump steam valve. Attached to the top of the can, which is open, is a headed extension arm. This head engages with the catch blocks which are secured to the spring, and holds the can in position until a predetermined weight of water has flowed into the can from the three-way valve.

The operation is simple. The engineer or boiler-room attendant starts the pump by pushing the steam valve lever to the position shown and then goes about his business without fear that the tank will overflow and waste water. When the tank becomes sufficiently full for water to flow down through the overflow or telltale pipe, the three-way valve being open to the outlet, water will flow into the can, and as soon as the weight of the water and can overcomes the tension of the springs against the projection on the extension, the can descends, closing the valve on the steam pipe supplying the pump.

Connected with the bottom of the can is a pet-cock which permits of emptying the can into the small funnel connected to the telltale pipe below the three-way cock or valve. A small check valve should be placed in the funnel pipe so that the water will readily flow into the telltale pipe, but as soon as the water ceases flowing the flap of the valve will close, thus preventing sewer gas from entering the engine or boiler room.

The second device is a little more complicated. It consists of an ordinary house pump or fire pump and a similar can-tripping arrangement, but in addition there is an oil cylinder which prevents the valve from slamming shut too hard against the valve seat.

Referring to Fig. 2, the pump steam pipe is fitted with an ordinary globe valve, the stem of which is extended beyond the valve wheel and on which a ratchet wheel revolves. A removable pin permits of operating the throttle valve independently of the ratchet. Attached to the ratchet is a sheave wheel over which a cord is wound a sufficient number of turns to permit the weight to fall far enough to close the valve when the pawl releases the ratchet. The ratchet wheel is fitted with a pin to which a crank is connected at one end and at the other to the piston rod of the oil cylinder. The ratchet is attached to a cord or chain that holds the can in position, as shown. In this instance the can springs and method of filling and draining are the same as in Fig. 1.

If the pump is attached to a water tank on the roof, as is frequently the case, it can be allowed to run without attention, as the device will operate as soon as the water flows into the telltale pipe. When this occurs, water will flow through the three-way valve into the can and when the weight is sufficient the can will slip from the spring support, lifting the pawl from the ratchet wheel, and the weight will close the valve, thus shutting off steam.

Here is where the oil cylinder comes into play. It is made with a piston, as shown, and a bypass pipe on the top of the cylinder. One end is fitted with an elbow and the other with a tee and a plug through which oil

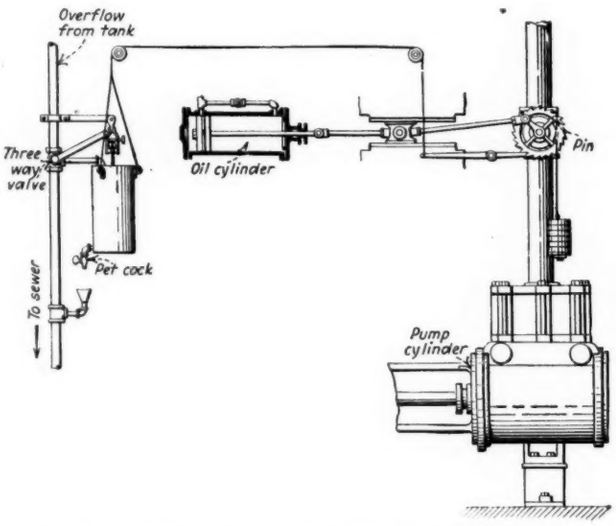


FIG. 2. PUMP-STOPPING DEVICE FITTED WITH OIL CYLINDER

is supplied to the cylinder as found necessary. As soon as the ratchet wheel is released by the pawl, the weight turns the valve and its motion is transmitted to the crank of the oil-cylinder piston, thus pulling the piston toward one end of the cylinder and forcing oil from that end into the other. The velocity of valve closing is regulated by a valve in the bypass, and when properly regulated, the steam valve will close without sudden shock or danger of injuring the disc or valve seat. The tension of the spring holding the can, Figs. 1 and 2, is regulated by a thumbscrew.

J. REDMOND.

New York City.

Insulating Varnishes for Motors

H. Wilson's article, "Treatment of Direct-Current Motors," in the Jan. 4 issue of *Power* is of particular interest, since the subject of insulating varnishes seems to be one not as extensively treated in the periodicals as it might be. It involves a knowledge of the properties of the various ingredients in the varnishes, their solvents, etc., and this is an industry in itself. The best that a layman can do is to get a general idea of the ingredients used, remember their various properties and then judge from his experience what is best suited for particular needs. Much is said about oils and varnishes, yet these two words do not mean the same thing to any two electrical men.

Lubricating oil may be of mineral, vegetable or animal origin, and when one speaks of oil attacking varnished insulation, it should be stated what kind of oil is used. Mineral oil, mineral greases and mineral compounds for lubrication do the least harm, while the vegetable and animal oils, whether mixed with mineral or used alone, turn rancid in time and gum and produce most of the undesirable results. Some greases are soaps containing metals and a fatty acid, which often turns rancid. Whenever oils have an offensive odor or turn rancid, they cease to be oils and begin to be acids. If, therefore, vegetable or animal oils and greases are used, a varnish that resists both acids and alkalies should be employed.

In brief there are two classes of varnishes: First, those that harden by driving off the thinner solvent which they contain and are sometimes called "spirit" varnishes; second, those that harden by chemical changes into hard films by absorbing oxygen from the air.

Considering both classes of varnishes and keeping in mind the electrical requirements demanded of them (melting points, rate of drying, character of the film produced, etc.), we shall find that in order to produce all these characteristics certain catalyzers have been used, to speed up drying and the production of a film. Right here is the cause of a great deal of trouble to the electrician. It is these catalyzers that are found in copal, manilla, kauri, resin, boiled oils, etc., that usually give trouble. This trouble is brought about either by the vegetable or animal lubricating oil turning rancid and forming salts, or when the electric current is passing through the copper an electrolytic action is set up, depending upon what kind of metal is present in the catalyzer. In this latter case this action through the insulation in time breaks it down, and on examination a copper salt is usually found in the form of a blue or green coating on the insulation. It might be mentioned that compounds of the metals, lead, manganese, cobalt, nickel, zinc, etc., are used as catalyzers. In the electrochemical series all these elements will be found to be electro-positive to copper.

Mineral oil penetrating into insulation will not do any harm, and if the insulating varnish is of the right composition it will only tend to make it more flexible. That mineral oil will not do a great deal of harm need not be told to electricians who use the oil in transformers.

A so-called compound from paraffin base has been said to be used in England for an insulating varnish, and it is claimed that it has no affinity for oil and yet is very flexible, etc. Chemically, this is erroneous, as paraffin is the base of oils and therefore could not be oilproof. In all probability it is a bitumen compound, and a little mineral oil, if it is used, will do no harm.

Another idea exists among electricians that if a linseed-oil varnish is used, lubricating oil will cause rapid oxidation and make the varnish brittle and porous. On the contrary, most oils will retard the oxidation of linseed oil, thus giving rise to a more flexible varnish because the higher the degree of oxidation the harder the varnish.

E. S. BAXTER.

Boston, Mass.

Superpower-Station Steam Pressure

With reference to the article by John A. Stevens in the Feb 1 issue and the letters by P. Hoffman and J. B. Crane in the March 15 issue, on a similar subject, I would like to call to attention the fact that these letters have a bearing on a moot question at present with the American Society of Mechanical Engineers, with relation to what is meant by "efficiency of a turbine," "efficiency ratio," "cycle efficiency," etc.

It appears that at present engineers as a class do not use these words alike and that a real need exists for a definition that will be accurate and of practical application. In the two letters mentioned, reference is made to Rankine-cycle efficiency, thermal efficiency and actual turbine efficiency. A cursory reading of the points raised in this discussion shows clearly the absolute need for a clarification of this matter. If, in addition to the points raised over the discussion on the article by Mr. Stevens, it were shown that large turbines can be made for operation on a Carnot cycle and thereby obtain some 16 per cent, or more, increase in thermal efficiency, the matter would be still further complicated. I wish to submit the following:

All steam cycles, including Rankine, Carnot, etc., are theoretical conceptions, and their efficiencies denote the ratio of heat that can be converted into work to the total heat supplied in the steam.

In thermodynamics a perfect engine is used. By being perfect, it has an efficiency of 100 per cent and is a conception whereby the heat of the steam which can be converted into work is so converted in the definition.

The efficiency of various possible cycles, including the Rankine and Carnot, are readily obtained from data on steam.

When the cycle efficiency is multiplied by the efficiency of engine or turbine, the thermal efficiency for the combined cycle and engine is obtained from the two fundamental conceptions as a derived result:

First, cycle efficiency, or the thermodynamic efficiency of a perfect engine, as given in the thermodynamic textbooks.

Second, the engine or turbine efficiency, which is a measure of the perfection of performance of the machine and indicates the amount by which the machine approaches perfection. In other words, the efficiency of the machine is unity when all the available heat from the cycle is converted to work, and in the case of a practical engine in which 70 per cent of the available heat is converted to work, the 70 per cent ratio of conversion is the efficiency of the engine or turbine.

This figure of 70 per cent is a real property of the engine and is not a property of the cycle employed. If the engineering fraternity will adopt the fore-

going suggestion, the writer believes the existing confusion will be overcome, and his recommendation is that the thermodynamic cycle, or perfect engine efficiency, be combined with the practical engine efficiency, the product of the two being equal to the thermal efficiency. In this way the efficiency of the engine is deduced from a test by dividing the tested thermal efficiency by the calculated cycle efficiency. It differs from the definition of "efficiency ratio" in that the cycle efficiency actually employed on the machine, whether Rankine, Carnot or a combination, is employed as divisor of the thermal efficiency in place of the Rankine-cycle efficiency as defined for "efficiency ratio."

When the engine is operating on a Rankine cycle, the figure obtained is the same as that of the "efficiency ratio" and is the practical efficiency of the machine. If, however, a Carnot cycle is employed by the actual engine, the efficiency obtained in the manner mentioned takes proper care of this fact. If the design of a Carnot-cycle machine be as well perfected as a Rankine-cycle machine, the efficiencies will be identical even though the thermal efficiencies are very different.

If a turbine be constructed for operation on a Carnot cycle and tested, and then its tested thermal efficiency be divided by the efficiency of a Rankine cycle, the result is meaningless. The figure obtained in no sense is indicative of the performance of the turbine and is of no use to compare this turbine with other turbines, since it contains a general mixture of Rankine- and Carnot-cycle efficiencies with the actual turbine efficiency. Nevertheless, this meaningless figure is at present, by definition, the "efficiency ratio" of the machine.

C. H. SMOOT,
Rateau Battu Smoot Co.
New York City.

Making Steam With Fuel Oil

In *Power* for Dec. 14, 1920, page 935, you published an article of mine entitled "Steam Making With Fuel Oil," inadvertently omitting my name. That article was intended to present results of certain official tests of horizontal return-tubular and Babcock & Wilcox boilers in every-day operation, using fuel oil. I deduced a conclusion, which may be justified or not, depending upon the viewpoint of the reader. The opinion was assuredly justified by the record in the plants in question, for continuous tests were run on the two plants for an entire year, and the six official runs confirmed the daily plant tests, differing by less than 2 per cent therefrom. The continuous tests were under the direction of two engineering graduates from Cornell, representing the parties to the year's oil contract.

In the issue for Jan. 18, 1921, George S. Blankenhorn and in the issue for Jan. 25, Warren B. Lewis criticise my conclusions, asserting that fuel oil shows better results than I found. The former criticises me for not publishing the CO_2 records, asserting that he was a party to two of the tests I gave, and that the results were from 4.9 to 9.2 per cent CO_2 and that the furnace settings were for coal and not especially for fuel-oil burning, and that they were in very bad condition.

As to the settings, those for the water-tube boilers were in superb condition when the stokers were replaced by oil burners, being practically new and used only a few months. I examined and reported upon their condition before the oil fuel was started. The settings for the horizontal return-tubular boilers, built in 1908 when the boilers were constructed, were divided into two batteries of four and three boilers respectively. The boilers were set with a return pass over their tops. I examined these settings just before burning of fuel oil began and found them to be in fairly good condition, such as one would expect after a few years of service with current repairs kept up.

Coal tests on these return-tubular boilers, made at sundry times, gave results (with semi-bituminous) as follows in every-day service and operated by the regular firemen:

Evaporation Lb. from and at 212 Deg. F. per Lb. of Dry Coal	Evaporation Lb. from and at 212 Deg. F. per Lb. Combustible
10.57	11.85
10.38	11.82
10.15	11.55
9.70	11.08
10.03	11.19
9.80	11.03
Average 10.11	Average 11.42

These tests were made with various coals, some of which clinkered badly. They show results comparing favorably with those in other plants in every-day service. They would be called higher than usually obtains and are good commercial figures.

Before changing from coal to oil, comparative tests were run on two of the horizontal-tubular boilers, each of 24 hours' duration, by an oil engineer of experience (brought on from the Oklahoma fields to the Atlantic coast) and myself. The general results were as follows:

Test number	1,262	1,264
Fuel	Semi-bit. Coal	Fuel Oil
Sq. ft. heating surface of two boilers	3300	3300
Net evaporation from and at 212 deg. F., and available for mill use:		
Per lb. of dry coal, lb.	10.19	....
Per lb. of combustible, lb.	11.42	....
Per pound of fuel oil, lb.	....	12.567
B.t.u. per pound of dry coal	14,330	....
B.t.u. per pound of fuel oil	....	18,320
Combined efficiency of furnace and boiler, based on the steam made and available for mill use, per cent	68.98	66.57

It would not seem as though the old settings were in very bad condition just before the fuel-oil contract went into effect.

Another proof of the condition of the settings of the tubular boilers is found by the gas analysis on the test of Jan. 23, 1920, in which Mr. Blankenhorn participated, where the continuous records for the 24 hours showed CO_2 readings of 15 per cent maximum, 13 per cent minimum and 14.7 per cent average. These are the results of the chart readings as agreed to by Mr. Blankenhorn and myself.

My analyses have dissipated any idea one may have entertained as to the settings of the tubular boilers having been in bad order. As to the oil-burner settings, they were made under the orders and direction of Mr. Blankenhorn's clients and paid for by the owner of the mill. If they were not of the highest order of efficiency, then it is not from any lack of talent of the oil engineers or because they were in any way handicapped in opportunity for making changes. As a matter of fact the conditions were modified as to burners, settings, etc., from time to time, but without any apparent resulting advantage.

I have already noted that the water-tube boiler settings were practically new when the use of fuel oil began. But these settings became seriously damaged by the use of the oil fuel. During the year of such service the setting repairs made almost every Sunday, cost in excess of the initial settings, and the tube failures by blistering caused an expense greater that would have been incurred by twenty years of service with coal as the fuel.

Is it not strange that we never hear of the failures in boiler practice, but only of the big economies? During the last thirty years I have made 1,295 boiler tests, consuming some 15,000 hours, but I have not rushed into print with many of them, as they were of the commonplace, every-day kind. Occasionally, I have given a test where I had a $35-a-day fireman working to prove some guarantee for the builder. It would not interest readers to know that I got an evaporation of 8 or 9 or 10 lb. with the every-day conditions. The unfortunate part is that when some phenomenal result is obtained and published, there are so many who conclude that that is the ordinary thing. Where a fairly well-handled plant, using coal, oil or other fuel, gets a net efficiency of 75 to 80 per cent there are 5,000 plants getting under 70 per cent.

Can any reader give a record, worthy of credence and covering a year's operation with fuel oil or with coal, which shows as high as 70 per cent? I mean a net result, measured in steam available for the mill's use.

I know of a Corliss compound engine with condenser, using high-pressure steam and high superheat, which gave an indicated horsepower with 9.34 lb. of steam per hour, yet that same engine—tested to have tight valves and pistons—used about 16 lb. on three tests I have made of it since. One test was a dress parade and groomed affair to prove a guarantee, but the others show commercial conditions of operation. And just so it is with boilers. You can't get the dress-parade results in every-day use, and there ought not to be much dispute about it.

Accordingly, I again assert that no higher economy is had with fuel oil than with coal in the every-day plant, and the repairs are greater.

Philadelphia, Pa. JAY M. WHITHAM.

The Heating Plant As a Source of Power

The article on "The Heating Plant as a Source of Power" by Ira N. Evans in the Nov. 30, 1920, issue, contains some statements of general character which led the writer to investigate the subject matter of the article a little further. Mr. Evans, for instance, says that "the additional investment needed for this method of power recovery from heating steam is warranted in all plants of 500 hp. capacity and over." Also, "To estimate the possible saving, take 90 per cent of the boiler horsepower required in zero weather for heating and determine the period of time the current can be utilized. The product of these two figures will be the total kilowatt-hours that may be recovered, and multiplying by the prevailing cash rate for purchased current in the district will give gross saving for the year."

Mr. Evans states that the same type of fixtures and radiators as are employed in the steam system can be used in the hot-water system. Whether this is true or not depends entirely upon how liberally the steam-radiating surface had been installed, as it is a well-recognized fact among heating engineers that a hot-water system requires more radiating surface than a steam system provided both are designed with the same factor of safety.

Mr. Evans assumes the heating season of from 5,000 to 6,000 hours and further assumes that with one working shift per day, there will be from 2,500 to 3,000 hours of power operation; in other words, twelve hours a day of power operation and seven days a week during the heating season. He does not disclose the location of this ideal city where unions do not abound and where the working week is 72 hours long. The vast majority of us nowadays have to operate on either a 44- or 48-hour week. I would, therefore, change Mr. Evans' figures as follows: Heating season, Sept. 20 to May 20, 8 months = 34 weeks + 2 days = 240 days = 5,760 hours; holidays included in period, 4; net working period, 34 weeks less two days; power operation working one shift:

With 44-hour week = (34 × 44) — 16	1,480
With 48-hour week = (34 × 48) — 16	1,616
	2) 3,096
Average power operation hours	1,548

Using Mr. Evans' figures, liberal though they are, I would refigure his first plant on which he shows a saving of 37½ per cent as follows: Assuming that his power-generating plant is of a fairly modern type embodying well-recognized, good engineering practice, we would take the boiler pressure at 200 lb. absolute, with 150-deg. superheat.

Power recovery = 1,548 × 500	774,000 kw.-hr.
Gross saving from power at 1c. per kw.-hr	$7,740

Against this gross amount be charged:

Additional coal to make heating steam available for power purposes, which Mr. Evans says theoretically is 10 per cent, assuming a high figure of 10 lb. evaporation and $6 coal, $\frac{34{,}500 \times 0.65 \times 1{,}548}{10} \times 0.1 \times \frac{6}{2{,}000}$	1,041.42
Repairs, oil, supplies, etc., taken at a low figure of $0.0001 per kw.-hr. is 774,000 × 0.0001	77.40
	1,118.82
Use	1,119.00
Net saving from power recovery	$6,621.00
Investment required:	
Two 500-kw. units at $50 per kw	$50,000.00
Boiler plant assumed to have four 333-hp. units, giving one spare. To adapt the equipment for higher pressure and superheat required additional invesment over low pressure heating as follows:	
For higher pressure, per hp	$5.00
For superheat, per hp	5.00
Total additional boiler investment (1,332 × 10)	13,320.00
Total additional investment	$63,320.00
Return on investment $\left(\frac{6{,}621}{63{,}320}\right)$ per cent	10.47

In the second plant outlined by Mr. Evans, in which he installs a system for using forced-water circulation, a table which he gives evidently contains a misprint, as he indicates the use of a heating system with 75 deg. outside temperature. Presumably this is intended to be 65 deg. outside temperature. The figures, as he gives them, contain some most extraordinary condenser operation, as under the column headed 75 deg. outside, the terminal difference on his condenser is only 1.15 deg. F. This is shown as follows:

TEMPERATURE DIFFERENCE IN CONDENSER, AS GIVEN UNDER 0 DEG. OUTSIDE TEMPERATURE

	Deg. F
3-lb. pressure	221.5
Temperature circulated water	210.00
Terminal difference	11.5
Under 75 deg. outside temperature, 28-in. vacuum	101.15
Temperature circulated water	100.00
Terminal difference	1.15

Good practice, as indicated in the article by C. F. Brau on the surface condenser in A. S. M. E. Proceedings for 1915, gives 10 deg. terminal difference as being correct. Therefore, with the circulating water at 100 deg., the vacuum temperature will be 110 deg. F. or 27.4-in. vacuum.

The saving shown under this form of equipment, using Mr. Evans' figures except for the correction previously noted with regard to vacuum, and with steam

again at 200 lb. absolute gage and 150-deg. superheat, would be determined as follows:

Total heat in steam at 200 lb. ab. and 150-deg. F. superheat, B.t.u.	1,283
Total heat after adiabatic expansion to 3 lb, B.t.u.	1,083
Heat available for power per lb. steam, B.t.u.	200
Heat per kw.-hr. at 35-lb. steam rate = 35 × 200, B.t.u.	7,000
Kw. load at 3-lb. pressure	5,000
When operating at 27.4-in. vacuum, assume 10 per cent better efficiency, then heat required per kw.-hr. at 27.4-in. vacuum = 7,000 × 0.9, B.t.u.	6,300
Total heat in steam at 200 lb. and 150 deg. F, B.t.u.	1,283
Total heat in steam after adiabatic expansion to 27.4-in. vacuum	968
Heat available for power per lb. steam	315
Pounds steam per kw.-hr = $\frac{6,300}{315}$ = 20 lb	
Kw. load at 27.4-in. vacuum = $\frac{69,000}{20}$	3,450
Average power recovery = $\frac{5,000 \times 3,450}{2}$	4,225
Average power recovery = $\frac{4,225}{5,000}$ = 84.5 per cent of maximum	

Mr. Evans states that this is "evidently 90 per cent." Using his method of computation, the *average power recovered* = 0.845 × 1,000 × 1,548 × 0.65 = 850,000 kw.-hr.

Gross saving at 1c. per kw.-hr.	$8,500.00
Against this gross saving must be charged the same amounts as shown for the first example	1,119.00
Investment required	$7,381.00
Generators and turbines, 2,000 × 50	100,000
Condensers and auxiliaries, 2,000 × 10	20,000
Boilers, etc., as above	13,320
	$133,320
Return on investment $\left(\frac{7,381}{133,320}\right)$ per cent	5.50

Even the savings given, which would hardly warrant a business man investing his money in the equipment when he could make one and one half to three times as much on the same money if invested in his legitimate business, are contingent upon the following conditions:

1. That he can hire licensed firemen for the same price that he can unlicensed firemen to operate low-pres-pressure heating boilers.

2. That he can add the generating equipment and pumps for circulating the water to his plant without adding an engineer to his plant organization.

3. That the theoretical increase of 10 per cent more coal to make the steam available for power purposes, as given by Mr. Evans at the top of page 847, would work out in practice, that is, the increased operating costs would be no higher than the theoretical costs, the operation being 100 per cent perfect.

4. Mr. Evans assumes that the water rate on his turbines is a straight line for different loads, which is not the case.

5. Mr. Evans assumes that the heating load synchronizes with his power load. As it is always necessary to start heating up the factory before the employees arrive in the morning, this, again, is not the actual condition.

6. Mr. Evans includes no cost of power for pumping the water through the hot-water circulating system, although he clearly indicates that such power is necessary. This power would form no inconsiderable expense, which I have omitted, as even without this expense the proposition is not able to stand on its own feet.

It should be noted that in the first example given by Mr. Evans, while he states at one point that a manufacturer would have to install double equipment, yet when he comes to determine the manufacturer's investment in his own plant he apparently has forgotten that double equipment is necessary.

In his second example, in spite of the fact that he has added condensers, circulating pumps, etc., to the equipment over and above the equipment required for the non-condensing plant of the first example, yet his unit price is $50 in both cases. Up to date the writer has been unable to purchase condensers without cost.

R. D. DeWolf,
Chief Operating Engineer,
Rochester, N. Y. Rochester Gas & Electric Co.

Labor Saving in the Plant

A. C. Lindon's remarks on labor saving in the Feb. 22 issue, page 319, apply wherever labor-saving apparatus has been installed. The trouble seems to be that the men who would profit most by the use of labor-saving machinery—the officers of a company—know least about the opportunities for saving. If the engineer asks for more or new equipment, he is too often told that he is trying to save himself trouble, that he is passing the "buck" or that he was hired to run the plant and not design a new one.

I was employed in a plant in Ohio containing five boilers. These were originally hand-fired, but later underfeed stokers were installed. Coal was delivered by railroad car to the entrance to the boiler room, where it was dumped. It was shoveled across the boiler-room floor nearer to the stoker hoppers, and then shoveled from the pile on the floor into the hoppers.

The installation of stokers doubled the boiler-room capacity, which was needed, but also called for additional labor, because of the greater quantity of coal burned. Had mechanical coal-handling equipment been installed, two men could have run the plant instead of there being sometimes six colored laborers shoveling coal.

The boiler-room doors had to be opened while coal was being transferred from the railroad car to the stoker hopper; the room was so cold during severe winter weather that everyone had to wear his coat. This meant that the air going to the fuel bed was of outdoor temperature instead of being 50 to 60 deg. as it would have been had it been possible to keep the boiler room closed. Right here was a loss of efficiency of about 2 per cent.

I tried very hard to have a coal-handling installation put in, but to no purpose. What we wanted was a portable conveyor that would pick up the coal from the floor and put it into the stoker hoppers.

I know of a plant in Chicago containing four boilers equipped with chain-grate stokers. The coal comes in railroad cars and is dumped in the yard. From there it is moved by a portable conveyor into the boiler room to a pile on the floor. The conveyor is then pushed into the boiler room and is used to move the coal from the pile to the stoker hoppers. In this plant one conveyor is doing both jobs and has cut the labor force involved. The method is rather primitive compared with some perhaps, but it saves money The portable conveyor offers a good solution in many plants where radical changes cannot be made; perhaps it is the best investment.

I believe that the best way to make the higher-ups appreciate that money can be saved by the purchase of equipment is to find some local plant that is using the equipment, determine how much this plant is saving and then try to have the "higher-ups" inspect it. I have found that engineers are generally proud to have their plants held up as examples of how things should be done, and in this way they may be very active salesmen.

Cicero, Ill. B. W. Smith.

INQUIRIES OF GENERAL INTEREST

Reclaimed Cylinder Lubricating Oil—Is oil that is collected by the oil separator of an exhaust steam heating apparatus suitable for use over and over in the engine as cylinder-lubricating oil? P. H. B.

Oil thus reclaimed and thoroughly cleaned of dirt by filtration or by a centrifugal separator is found to be as good for engine cylinder lubrication as when first used for the purpose.

Chattering of Check Valve in Boiler-Feed Line—What causes continual chattering of a 2-in. check valve on a boiler-feed line? W. H. P.

Chattering occurs because the rate of discharge through the valve is not sufficiently large and continuous to hold the valve open, especially occurring when the rate of discharge is low and conditions are favorable for vibrations of the pump to impart impulses of pressure to the water.

Inside and Outside Lap of D Slide Valve—What is the reason for having inside and outside lap on a D valve? W. E. G.

The main purpose of providing the D valve of an engine with outside lap is to obtain cutting off of the supply of steam to the cylinder when the piston has completed a fractional part of a power stroke; and the purpose of providing inside or exhaust lap is to obtain closing of the valve to exhaust before completion of an exhaust stroke. In both cases the lap must be considered along with the operation of the eccentric.

Excessive Length of Pump Suction Line—For pumpage of 200 gallons of water per minute would it be practical to have a 6-in. pump suction line 1,700 ft. long with a suction lift of 8 ft. at the supply end? D. J. R.

It would not be practical, as the pipe would soon become airbound from liberation of air out of the water during over 12 minutes time required for the suction water to travel the length of the suction line with reduction of its pressure. The total loss of head from pipe friction would be about 6¼ ft., and the average pressure of the water would be about $(3\frac{1}{4} + 8) \times 0.433 = 4.87$, or approximately 5 lb. per sq.in. below the pressure of the atmosphere.

Size of Pump Air Chamber—What should be the size of air chamber for a boiler-feed pump? H. C.

For single direct-acting crank and flywheel pumps, satisfactory results usually are obtained with air chamber capacities six to eight times the pump displacement, and for duplex pumps, three to four times the displacement. When air is confined under pressure and in contact with water, the air becomes absorbed by the water unless the water is already fully aërated, hence the larger the air chamber the better. But to insure the benefit of an air chamber it is of greater importance to have it full of air before starting the pump than to provide the air chamber with large capacity.

Relative Economy of Natural Gas or Coal as Fuel—What would be the economy in generation of steam using natural gas costing 24.5 cents per 1,000 cu.ft., compared with coal containing 13,000 B.t.u. per pound and costing $3 per short ton, delivered at the boilers? E. M. C.

In addition to the data quoted, the relative economy would depend on the B.t.u. contained per 1,000 cu.ft. of the gas, taken with the cost of attendance as compared with the cost of handling and firing the coal, handling and disposing of the ashes and the relative boiler and furnace efficiencies attained. Assuming the heat value of the gas to be 1,000 B.t.u. per cu.ft., the cost of the gas would be 24.5 cents per million B.t.u.; and with coal containing 13,000 B.t.u. per pound and at $3 per short ton, the cost woud be $\frac{300 \times 1{,}000{,}000}{2{,}000 \times 13{,}000} = 11.5$ cents per million B.t.u. Considered solely with reference to the heat values of the fuels, that of the gas being assumed as 1,000 B.t.u. per cubic foot, the cost of the coal would be about 47 per cent that of natural gas.

Power Transmissible by ¾-In. Shaft.—What number of horsepower can be safely transmitted by a steel shaft ¾ in. in diameter and 10 in. long, running 800 r.p.m.? Does the length make any difference? H. N.

The safe number of horsepower transmissible by a cross-section of the shaft is given by the formula, $D^3N \div 100$, in which D is the diameter in inches and N is the r.p.m. Hence where $D = \frac{3}{4}$ in. and $N = 800$ r.p.m., the safe load would be $(\frac{3}{4})^3 \times 800 \div 100 = 3.38$ hp. The length of shaft is immaterial, provided the bearings are so spaced that the deflection when running does not exceed 0.01 in. per ft. The number of horsepower transmitted at any section must be construed to include the power required to overcome friction of the bearings beyond that section.

Parallel Operation of Steam- and Water-Driven Alternators.—Cannot a three-phase 60-cycle 600-volt 350-kva. 22-pole alternator, direct-connected to a water turbine with a speed of 327 r.p.m., be operated successfully in parallel with a three-phase 60-cycle 600-volt 150-kva. 8-pole alternator belted to a lineshaft driven by a Corliss engine; and would it be advisable to cut out the governor on the waterwheel and let the steam-engine governor do all the speed regulation? P. E. M.

The machines should operate successfully in parallel if they are free from outside disturbances. Some trouble might arise, however, if several large machines subject to rapid fluctuations of load were driven from the same lineshaft as the engine-driven unit. Sudden speed changes resulting from this arrangement might pull the alternators out of step. This is not probable, however, for a belt drive is a relatively flexible connection, particularly if it be run somewhat loose to allow a little slipping in case of sudden load changes.

It would not be advisable to disconnect the waterwheel governor unless certain that the load will not drop below full load of the waterwheel unit. Should this occur with the waterwheel governor disconnected, the speed and frequency would rise materially above normal. The waterwheel governor should be adjusted to maintain full gate opening up to the speed corresponding to no-load on the steam engine and to begin closing the gates above this speed. The steam engine will then carry only that portion of the load that the turbine cannot carry.

The Present Position of the Marine Diesel Engine

By James Richardson*

Many engineers have now become familiar with the leading principles of internal combustion, and more Diesel work has been undertaken at home within the last few years, due to submarine naval requirements, than in any previous period. Many of the salient points are now appreciated, and growing interest is stimulated and met by the technical literature increasingly available.

Experience during the war with submarines also showed the four-stroke-cycle engine in a favorable light. Where reduction of weight, compactness, maximum power per unit volume of ship occupied by internal-combustion machinery were the chief considerations, the four-stroke-cycle principle was found fully to meet the requirements. In Germany the two-stroke-cycle engine was most favored for marine work prior to 1914, but for submarine propulsion during the war this system was gradually dropped. Ultimately, by far the larger number of German submarines and all having the highest power per unit had four-stroke-cycle engines. In the British navy the four-stroke-cycle principle was almost exclusively adhered to.

Oil-Spraying Systems

There are two alternative methods of spraying—one by means of compressed air, the other by injecting the fuel at a high pressure, known as the solid-injection system. The utilization of compressed air is most general. So far as marine installations are concerned, the principal advantage of the solid-injection method, where compressed air is not used to assist injection and is only required for supplying maneuvering power, is that the compressors are not a part of the main propelling engine and do not require to be run continuously at sea. Moreover, the air-compressing plant, where solid injection is adopted, can be reduced by from 40 to 50 per cent in capacity.

Reliability with air compressors delivering at 850 to 1,000 lb. per sq.in. has now reached a high level, the leading factors toward this end being generally appreciated, and air-compressor problems rated at their full value. Multi-staging is essential, and compression to 1,000 lb. per sq.in. should be carried out in not less than three stages, so proportioned that no undue ratio of compression and consequent temperature can occur in any stage. Particularly should the first, or low-pressure, compression be minimized. Such rises of temperature as are inevitable with compression should be reduced by efficient cooling of the air during compression and by the installation of intercoolers and aftercoolers to reduce to atmospheric whatever temperature remains after compression. Removal of moisture from the air should be facilitated. Every effort in design should be made to insure that the compressor valves and springs can be easily removed and replaced.

The other fundamental of injection, the measuring of the oil fuel, involves the most delicate apparatus associated with the Diesel oil engine—the fuel injection pumps and controlling gear. The system of having one pump per cylinder is now almost universal for marine work (excepting where solid injection is used) and only in this way can the maximum security against a large percentage of overcharge and overload in one or more of the cylinders be obtained. Even with separate pumps continual care and intelligent supervision must be exercised to insure that the deliveries from the pumps are maintained equal, lest one or more cylinders should be overloaded to counteract the effect of diminished deliveries from defectively working pumps. Means are now generally provided whereby any pump can be cut out and overhauled while the remainder are in operation.

Cylinder-Temperature Problem

The Diesel engine remains a heavy and expensive prime mover in comparison with its steam rivals. Even with the progress made in design within the last six years, it can definitely be stated that there has been generally an increase in the weight and the space occupied by the slow-speed Diesel engine per horsepower developed continuously. The factors opposed to a reduction of these disabilities and rendering difficult the path toward the higher powers now desired, are the temperature gradient through the metal surrounding the combustion chamber and the fact that the major portion of the material of the engine is utilized only for a small fraction of the running time. The former refers particularly to the two-stroke-cycle, and the latter to the four-stroke-cycle engine, where three-quarters of the running time is idle so far as power output is concerned.

For a better utilization of materials than is achieved with the four-stroke-cycle engine, the two-stroke-cycle single-acting, the four-stroke-cycle double-acting, the opposed pistons construction, the two-stroke-cycle double-acting principles or the combined effect of oil and steam, as with the "Still" engine, are put forward. However attractive may be the mechanical arrangements so facilitated, the Diesel oil engine is a complicated machine highly loaded and stressed by high-pressure combustion within the cylinder, and short cuts to achieve reduction in space, weight and cost will be fruitful only in so far as first principles and fundamentals, more especially in respect of rate of heat transmission, are not violated.

Reliability of the Diesel

That after ten years of experience, keeping in view the last five years of intensive service, reliability can be obtained with the Diesel engine will not be gainsaid. The position of this new prime mover is not yet, however, sufficiently secure for short cuts toward the lightening or cheapening of the engine to be undertaken without the most careful consideration. The available knowledge demands that oil engines shall be rated at a moderate power output per unit of swept cylinder volume with the consequent low-temperature gradient through and low stresses in the metal exposed to combustion temperature.

Ample strength and rigidity must be given to those parts that are stressed by the pressure of the cycle, and a high quality of workmanship is essential for all the principal units. So long as labor conditions do not very appreciably change, the Diesel oil engine will increase rapidly in importance, with the full realization of the enormous advantages of liquid fuel as a marine combustible. Satisfactory distribution of fuel throughout the world seems assured, and any future shortage will first affect those plants less able to compete in regard to economy of consumption of liquid fuel. Powers up to 6,000 brake horsepower or even 8,000 brake horsepower per ship with twin screws (500 brake horsepower per cylinder) can be looked for in the very near future, and gradual increases will take place successfully by short steps consolidating each advance as gained, before proceeding to the attainment of higher outputs.

Under the entirely new conditions now operating it is pleasing to reflect that in Great Britain there are under construction a larger variety of types of marine oil engines than in any other country, indicating an enterprising and progressive policy of determined trial. This is in strong contrast to the apathy with which we were charged before the war. Experience with these engines will go far to enable relative values to be given to various systems and types of construction. In time a few may be eliminated, as has been the case with other prime movers, but the majority will remain until gradual development and increased application enable a high plane of performance to be reached, when the issue will become narrowed down.

In the future the claims of the Diesel-electric system of propulsion will receive much more attention than hitherto, and this may prove the most secure path toward high power. Whatever the merits of steam-electric marine installations, the case for the Diesel-electric, so far as the mercantile marine is concerned, is much stronger.

*Extracted from a paper read before the Institution of Engineers and Shipbuilders, in Scotland, Oct. 19, 1920.

Exports of refrigerating machinery, including ice-making machinery, during January, 1921, were valued at $318,103, as compared with $212,059 for January, 1920. The figures are from Bureau of Foreign and Domestic Commerce.

Corrosion of Boilers

In the course of a recent lecture before the Institution of Mechanical Engineers (London) Sir John Dewrance exhibited a little boiler designed to demonstrate the heat-absorbing capacity of water tubes. It was fitted with a full-bore Babcock tube about three feet long and worked with a coal and coke fire under a very powerful draft. It was possible to evaporate water with this boiler at the rate of 150 lb. per sq.ft. of heating surface per hour, which was, of course, far in excess of the generally accepted idea as to the extent to which boilers could be forced.

In reporting the lecture *The Engineer* quotes Sir John as stating that in land plants corrosion was not such a serious problem as it was at sea, as it was comparatively easy to get reasonably good water ashore; but afloat there were three sources of corrosion to fight against. These were magnesium chloride, air and oil. Lime was classed by some engineers as another cause of corrosion, but he would not deal with it, as he considered that in any well-attended plant lime would never be allowed to enter the boilers. Magnesium chloride was the cause of much trouble

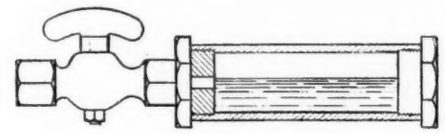


Fig. 1

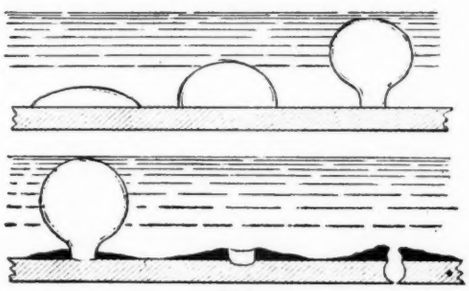


Fig. 2.

FIG. 1. EXPERIMENTAL TUBE TO DETERMINE CORROSION FROM MAGENSIUM CHLORIDE—FIG. 2. CORROSIVE ACTION OF MAGNESIUM CHLORIDE

at sea, as it attacked the heating surfaces and caused severe corrosion. This action, however, did not take place in other parts of the boiler and it was the subject of much speculation at one time, as to why the heating surfaces only were attacked.

In order to confirm this fact, a short length of polished boiler tube was capped—as shown in the accompanying sketch (Fig. 1) and half-filled with a strong solution of magnesium chloride. The air above the solution was exhausted and the whole device immersed in a hot bath for a considerable period. When the tube was opened again and examined there was no trace of the surface level of the solution on the walls of the tube, showing conclusively that the chloride in solution did not attack the steel tube. One day, on glancing around his laboratory, Sir John noticed a dark-red ring around the edge of a pan in which a solution was being evaporated, and that suggested to him the real cause of the corrosion. The red discoloration, which was evidence of the iron being attacked, was present only where the solution had dried out. The corrosion of the boiler-heating surfaces was caused by dry manganese chloride, but the problem was, How could the chloride become dry below the water level?

In his explanation of this phenomenon the lecturer used the diagrams shown in Fig. 2. There were always, he said, peculiar spots in boiler plates which steam bubbles preferred as the site of their appearance. They might be caused by a slight reduction in the thickness of the plate, the flaking off of a piece of scale and a small flaw, but these special places always existed. On the left, at the top of the sketch, a bubble was beginning to rise off the previously wet plate. Any magnesium chloride that might be evaporated out of the water in the formation of the bubble would be deposited on the plate and would be dried out under the protection of the bubble. Finally, the bubble would escape, as shown, and the plate would be wetted again. During the time that the chloride was dry it would, at the temperature of boiling water, produce hydrochloric acid, which would "bite" into the plate. The action then proceeded as shown in the lower sketch. A little crater was formed, surrounded by a heap of oxide, which was thrown out by the explosion of the bubbles, and finally developed, as indicated on the right, into a pocket with a narrow opening in which the acid was boiled. Ultimately the plate was eaten entirely through.

Industrial Use of Fuels with High Ash-Content*

The products obtained from bituminous coal mines may be classified in three groups. Fuels with 5 to 25 per cent ash, those with 25 to 50 per cent ash, and those with 50 to 80 per cent ash, the last including shales and refuse from sorting, crushing or washing operations.

The second-class fuels, with 25 to 50 per cent ash, are being used to a certain extent in boiler furnaces, both hand- and stoker-fired, but the efficiency of combustion is low, and 20 per cent at least of combustible matter usually remains in the ash. Fuels of this class rich in volatile matter may be more economically handled as coke in ordinary gas producers, after preliminary distillation to extract the tar and other byproducts. But those with low volatile content are not suited to this method, and their treatment in gas producers in which the ash is completely fused, of the Sepulchre and Marconnet types, has been tried, but is still in the experimental stage. The utilization of the poorer fuels, from 50 to 80 per cent ash, is still farther from realization.

The object to be attained in gas producers of all types is to transform the combustible matter in the fuels, either by distillation or by partial combustion, into gases with the maximum content of CO. In the Sepulchre and Marconnet producers, the elimination of clinkers is attempted by complete fusion of the ashes, using a flux and higher blast pressures. The results are unsatisfactory, as no means has yet been devised to avoid the formation of clinkers around the tuyeres. This is due to high temperatures, approaching 3,600 deg. F., caused at this point by combustion of the carbon to CO_2. Several methods have been tried to avoid the formation of CO_2, such as the admixture of steam to the air blast; but the only successful method seems to be that of heating the air blast. If it were possible to raise the temperature of the air to 1,800 deg. F. before it enters the furnace, nothing but CO would be produced. The whole problem of the utilization of high-ash fuels in gas producers therefore rests upon the possibilities of heating the blast. The higher the ash content, the higher the temperature required to avoid clinker formation. This has been successfully accomplished by A. Dessemond in the laboratory with ash contents above 50 per cent, but the limiting condition in the distillation of shales and other poorer fuels seems to be that the mixture of fuel and flux must contain at least 14 per cent fixed carbon.

The possibility of combining the manufacture of cement with the treatment of shales in gas producers is foreshadowed by Mr. Dessemond.

Up to the year 1834 only twenty explosions had occurred in America with high-pressure engines, while thirty-two had happened with low-pressure, and it is well known how common the high-pressure engine is in that country, particularly in the Western States. *Echo du Monde Savant*, No. 24, p. 178, published from 1834 to 1846 in Paris.

*Abstract from an article by M. Auguste Dessemond, in the *Revue de l'Industrie Minerale*, Jan. 15, 1921.

High-Current Tests on High-Tension Switchgear*

In connection with the study of very high-current electric welding apparatus, certain phenomena took place on the ordinary type of brush contacts, which prompted an investigation and subsequent tests to determine the behavior of circuit breakers used in central stations when subjected to currents of the order of 100,000 amperes, as may exist at times of short-circuits on large systems.

Series of tests were therefore made in 1918 and 1919 by the New York Edison Co., on oil circuit breakers and disconnecting switches, to determine their strength at brush contacts and supports in withstanding the mechanical stresses produced by the magnetic flux. Tests were also made on current transformers and potential-transformer fuses. For the first time a synchronized motion-picture machine and an oscillograph were coupled to reproduce the coincident action of the apparatus tested and the variations of voltage and currents in the circuit. Power for the tests was supplied by two 10,000-kw. generators, operated in parallel through a 3,850-kva. transformer, stepping the voltage down to 170 to 200 volts for direct application to the terminals of the switch gear under test. In all these tests the circuit breakers were locked in the closed position, for the investigation was not intended to cover interrupting operations. Therefore any arcing observed could be attributed only to the springing of the main and arcing contacts under heavy magnetic strains.

The tests proved that practically all the circuit breakers then on the market had the brush contact placed in the wrong position, so that when current flowed, the mechanical force produced by the magnetic field acted in a direction opposed to the brush pressure, thus tending to open the contact at this point; whereas, if the position of the contact brushes had been reversed, the mechanical force due to this current would have been exerted in the same direction as the brush pressure, thereby tending to improve the contact. In addition to the force exerted at the contacts, it was found that the repelling force between contact supports was of such magnitude as to distort, and in some cases permanently displace, these parts.

On the basis of the results obtained, the manufacturers have revised the design of their circuit breakers so that the magnetic strains will act to press the contact surfaces together. This has been accomplished either by inverting the brush contacts or by providing jaw-shaped contacts in which parallel paths carry current in the same direction, tending to draw the two together and so closing the jaw against the contact surfaces.

Summary of Tests on Oil Circuit Breakers

All the current values quoted are mean effective.

G. E. Co. K-52 Circuit Breaker reinforced with fiber band. Rating, 125,000 kva. 31,500 amp. 2,300 volts. Withstood 27,000 and 31,000 amperes, failed under 85,000 at ninth cycle, by spreading of porcelain pillars, breaking of one, and twisting apart of contacts.

Same as foregoing, reinforced with wood and steel. Withstood 67,000 amperes, failed under 98,000 amperes at twelfth cycle by breaking of porcelain. Total spread of contacts, $\frac{3}{16}$ in.

Same as foregoing. Test on arcing tips only. Contacts lifted under 21,000 amperes on first $\frac{1}{4}$ cycle, closed and lifted again, burning severely.

Westinghouse E-9 Circuit Breaker. Rating, 160,000 kva. 40,000 amperes 2,300 volts. Failed under 79,000 amperes, by lifting of brushes on first $\frac{1}{2}$ cycle, arcing then freezing closed. Total spread of contacts, $\frac{3}{32}$ in.

Same as foregoing. On 89,000 amperes, the brushes lifted on first $\frac{1}{2}$ cycle and burned clear in $8\frac{1}{2}$ cycles.

G. E. Co. H-3 with Inverted Brushes. Rating, 225,000 kva. 63,000 amperes 2,300 volts. Tested at 103,000 amperes, showed slight arcing at contacts due to vibration and spreading of pots; contact plates collapsed, one of the brass rods of the arcing tips burned off and switch open-circuited.

Same as foregoing, with trial brushes. Tested under 112,000 amperes. Slight arcing at contacts due to vibration, one brass rod bent; total spread of pots, $1\frac{1}{8}$ in.

Same as foregoing. Arcing tips burned off under 41,000 amperes in 0.57 sec.

Westinghouse O-1 Circuit Breaker. Rating, 350,000 kva. 88,000 amperes 2,300 volts. Tested under 63,000 amperes. Brushes lifted on first $\frac{1}{4}$ cycle, froze, then remained closed. Total spreading of supports, $\frac{3}{16}$ in.

Same as foregoing. Tested under 84,000 amperes. Brushes lifted on first $\frac{1}{4}$ cycle and continued intermittently throughout the test. One arcing tip destroyed. Considerable spreading of supports during the test, but no permanent spread was noted.

G. E. Co. H-6 Circuit Breaker. Rating 350,000 kva. 88,000 amperes at 2,300 volts. Tested at 130,000 amperes. Pots spread at first $\frac{1}{4}$ cycle; no arcing. Parallel paths through moving contacts cause attraction of contact fingers and tightening of contacts. Total spread of pots, about 1 in.

Tests were also made on disconnecting switches, current transformers and potential-transformer fuses, the last with the purpose of comparing the operation of fuses with and without resistance in series. As a result of these tests it is advised that resistance be used in series with fuses, that single-turn-primary current transformers be used, and that disconnecting switches be provided with powerful locking devices.

*Abstract of paper presented by Philip Torchio, chief electrical engineer, New York Edison Co., at the Ninth Midwinter Convention of the A. I. E. E.

California's Engineering Societies To Co-operate

Local sections of national engineering societies in California cities have been joining forces in matters of common interest for several years, and there is now in process of formation a state-wide body to be called the California Engineering Council, which will direct activity in which it would be desirable to have all the engineers combine. The idea of the state council grew out of the discovery that local organizations in San Francisco, Los Angeles, Sacramento and Fresno found matters of common interest in which there would be advantage in co-operation.

The San Francisco council is to consist of three members each from local sections of the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the American Chemical Society, the American Association of Engineers, the American Institute of Architects and the Pacific Association of Consulting Engineers. The local membership in the sections to be represented in this council aggregates approximately 2,000

It is the custom for such a body as this to take definite action, such as passing resolutions, drafting a letter of protest or otherwise speaking for the engineers as a whole whenever a matter is brought before it by one of the member sections that has been sufficiently concerned to take action itself. Matters of general interest to two or more sections are to be brought up in regular meetings of the council which are to be held every month.

For example in a recent situation in which the revision of the boiler code was desired, upon recommendation of the local section of the American Society of Mechanical Engineers, the San Francisco Engineering Council passed a resolution urging upon the Industrial Accident Commission of California the adoption of a code that would be in conformity with that approved by the Boiler Code Committee of the American Society of Mechanical engineers.

A scheme is said to be contemplated for the amalgamation of all the electric companies of Formosa. The available hydro-electric power in 1917 was only about 17,000 hp., but it is hoped through this consolidation to develop approximately 130,000 hp. There is a great quantity of coal on the Island; the amount mined in 1918 was 801,000 tons.

Washington News

Depreciation Section of Power Commission Regulations Discussed — Federation Opens Washington Office—New Water Power Applications Received

By Paul Wooton
Washington Correspondent

The regulations recently promulgated by the Federal Power Commission formed the subject of a hearing in Washington on March 25. The discussion was confined largely to Regulation 16, which deals with depreciation reserves. There is objection to the establishment of any depreciation reserves at all. The portion of the regulation that meets with most disfavor reads as follows:

The licensee shall, within six months after the date of going into service of any project, prepare and submit to the Commission a statement showing in detail the plan upon which it is proposed to charge depreciation, including the cost of the project, the property, and the cost thereof on which it is proposed to charge depreciation, and the property and the cost thereof which the licensee considers is not subject to depreciation and upon which no depreciation charges are proposed. Such statements shall further show as to each class of property, or structure, unit, or item when separately estimated, on which it is proposed to charge depreciation, other than deferred maintenance, its cost, its service life (estimated, if not known), the estimated value of salvage (if any) recoverable at the time of retirement, and the rate necessary to be applied to the cost of each such class of property, or structure, unit, or item, to produce a reserve equal to the difference between such cost and the value of salvage (if any) recoverable at the time of retirement. A schedule shall also be submitted showing a list of property, if any, and the cost thereof, on which it is proposed to charge depreciation representing deferred maintenance, the annual amount of such depreciation, the basis for determining such amount, and such other details as may be appropriate. Such classification of property and such rates and amounts of depreciation thereon so proposed shall be used by the licensee as a basis for charging depreciation, unless and until the Commission, after investigation and hearing, shall by order require changes in such classification and in such rates and amounts of depreciation.

Brief hearings on the regulations were held prior to their promulgation, but owing to the necessity of having the rules in force, so as not to delay the issuance of licenses and permits, it was decided to adopt them with the understanding that they could be amended later. The feeling of the Commission seems to be that the regulations should be allowed to go to the Public Utilities Commissions of the various states for their study and suggestion. During this time opportunity would be given everyone interested to study them and submit suggestions. With all the suggested amendments before it, the Commission then could undertake more intelligently, it is believed, the changes that might be found desirable.

Attitude of Secretary Weeks

In view of the vast amount of work confronting the Federal Power Commission, the Secretary of War is of the opinion that it would be better to have a commission that could devote all of its time to the work. Secretary Weeks stated that he had not considered delegating his place on the Power Commission to a subordinate, but that he believes it will be necessary for him to delegate some of his work so as to give the remainder the personal attention it deserves. Whether the Power Commission work or some other duty will be shifted to other shoulders has not been determined. Secretary Weeks stated that he will not make up his mind until he has sat in at a few of the Power Commission's meetings so as to determine the exact character of the task.

To have a commission that would devote all its time to water-power matters would require legislation. It also probably would require legislation for the Secretary of War to delegate the power to act to any of his subordinates. It would be possible, it is believed, for him to designate some officer of his department to sit in his stead at meetings of the Power Commission so long as the Secretary himself assumes final responsibility.

With the opening last week of its suite of offices in the National Savings and Trust Company building, in Washington, the Federated American Engineering Societies began to direct its work from the National Capital. L. W. Wallace, the executive secretary of the organization, has been in Washington completing the arrangements for the opening of the national headquarters. He will not be able, however, to take up his residence in Washington for another month, as he is busy in New York on the Federation's Industrial waste survey. In the meantime the offices will be in charge of A. C. Oliphant, the assistant secretary.

The principal effort being made at this time at the Washington offices of the Federated Societies is in connection with the extension of the employment service of the organization. In addition to having one central controlling office, the plan is to have branch offices in several of the larger cities. A full report on the employment service is to be made when the executive board meets in Philadelphia on April 16. Secretary Hoover, of the Department of Commerce, the president of the organization, expects to attend the executive board meeting. At this meeting a comprehensive report also is to be made on the activities looking to the establishment of a Department of Public Works.

Copies of a model bill on the matter of licensing engineers now are available at the office of the executive secretary. These bills are being sent out to those interested, not with the idea of offering a recommendation one way or the other in the matter, but in the hope that any state legislation that may be enacted will follow the general lines of the model bill, which is the result of extended study of the license law situation.

Water Power Applications

Applications received by the Federal Power Commission for the week ended March 19 were as follows: Southern Sierras Power Co., First National Bank Bldg., San Francisco, diversion High Creek, Vivian Creek, Falls Creek, Alder Creek and Lawson Creek, public utility; Copper Harbor Pulp and Power Co., Bank of Nova Scotia Bldg., Vancouver, B. C., power development Prince of Wales Island, Alaska, pulp mills; Yuba Development Co., 1213 Hobart Bldg., San Francisco, power development, North Fork, Yuba River, Nevada County, Cal., public utilities; Sand Springs Home, Sand Springs, Okla., power development, Grand River, Mayes County, Okla., public utility; Provident Irrigation Co., Willows, Cal., power development, Deer Creek, Tehama County, Cal., irrigation.

Mechanical Resonance Causes Two Breakdowns

An unusual cause of failure in the Dalmarnock Station, Glasgow, was reported by the Metropolitan-Vickers Electrical Co., Ltd., and published by *Engineering* on Feb. 18, 1921. Two 15,000-kw. turbo-alternators of the same capacity and design broke down within two weeks of each other from the grounding of one of the core bolts on the armature laminations. These bolts went through, and were insulated from, the end plates and the laminations. Signs of excessive vibration were found on nearly all the core bolts, and on the grounded bolt this trouble had become so severe that the insulation had been damaged and an arc set up from bolt to core. This vibration has been attributed to resonance betwen the bolt and the machine, the tension of the bolt having brought its natural period of vibration in the vicinity of that of the machine.

As a result of these findings, a third machine then under construction was provided with copper core bolts of smaller section to allow heavier insulation, the bolts being set under very slight tension in order to keep their natural period as remote as possible from that of the machine.

According to the United States Department of Commerce this country exported overseas during 1920 a total of 20,452,859 long tons of bituminous coal. This figure is a new high record for overseas shipment, but is, nevertheless, under 4 per cent of the total production.

Personnel Workers Organize

The Personnel Research Federation was organized March 15 at Washington under the auspices of the National Research Council and Engineering Foundation. Its purpose is to co-ordinate the activities of the 250 scientific, engineering, labor, management and educational bodies in the United States that are studying personnel problems, to collect personnel research information and to encourage such research through individuals and organizations. To accomplish this it will try first to learn what organizations are studying one or more personnel problems and what the scope of their efforts is, and later on to find out whether these efforts can be harmonized, duplication reduced, neglected phases of the problems considered and more advanced work undertaken.

Temporary officers were elected as follows: Chairman, Robert M. Yerkes, representing the National Research Council; vice-chairman, Samuel Gompers, representing the American Federation of Labor; treasurer, Robert W. Bruere, representing the Bureau of Industrial Research; secretary, Alfred D. Flinn, representing Engineering Foundation; acting director, Beardsley Ruml, assistant to the president of Carnegie Corporation of New York.

Boston Greets Engineers

Last week was Engineers' Week in Boston. On Tuesday the Boiler Code Committee and the Committee on Local Sections of the American Society of Mechanical Engineers were in session all day at the Engineers' Club. In the evening some thirty-odd of those who had been associated with John A. Stevens in the Council and Boiler Code Committee invited him to dine with them and tell them of his recent experiences in Europe.

On Wednesday the A. S. M. E. Council met at the Engineers Club and adopted the newly completed Locomotive Boiler Section of the Boiler Code. In the evening there was a joint session of the local section of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Harvard Engineering Society, at the Harvard Union, Harvard University, when Dr. Charles E. Lucke, of Columbia University, delivered an admirable address on "The Internal-Combustion Engine" and president Carmen of the A. S. M. E. spoke upon "The Engineer and his Opportunities."

The next two council meetings will be at Mobile, Ala., on April 22, and at Chicago, Ill., on May 23. The council has issued an invitation to the society's committee members to attend its meetings, which are held monthly and generally in different parts of the country.

Coosa River Project Under Way

The dam of the Alabama Power Co., at Duncan's Riffle, on the Coosa River, is now under construction, and it is estimated that it will be completed in about two years. It will be necessary to build an eight-mile railroad connecting with the Louisville & Nashville R.R. to carry material needed in constructing the dam, and preliminary work for this track is now being done.

It is expected that the dam will be about 1,500 ft. long and that it will raise the water level about 84 ft. The total horsepower that will be made available by the project is to be about 120,000.

Correction—The author of the article entitled "An Unusual Case of Thermit Pipe Welding," in the March 1 issue, calls attention to an ambiguity arising from an error of wording. The second sentence of the last paragraph, page 352, second column, instead of reading "This would not account for," etc., should have read "This would account for not every blister resulting in a hole."

Personals

J. F. Lary, who was for eight years superintendent of the Watson-Stillman Co's. plant, has accepted a position as assistant works manager with the Lidgerwood Manufacturing Co.

Alphonso Taurman has left the Virginia Railway and Power Co. and is now with the Birmingham Railway, Light and Power Co., Birmingham, Ala., as superintendent of equipment.

E. F. Pegg has opened an office at 827 Engineers' Building, Cleveland, Ohio, and intends to handle contractors' equipment of all kinds. Mr. Pegg has had twelve years' experience in this line in Cleveland and vicinity.

Society Affairs

Atlanta Section, A. S. M. E., will meet March 30 to hear John A. Stevens speak on "The Superpower Station."

The Textile Exhibitors' Association plans to hold an international textile exposition at the Mechanics Building, Boston, Mass., from Oct. 31 to Nov. 5, 1921.

Columbus Section, A. S. M. E., will meet April 8 at the Engineers' Club for a talk on "Combustion and Boiler Operation," by E. G. Bailey, of the Bailey Meter Co.

The New York State Association, National Association of Stationary Engineers, has announced that the 26th annual convention will be held June 9-11, 1921, at the Hotel McAlpin, New York City.

The Engineering Advertisers' Association, at its annual meeting held on March 8, elected the following officers for the ensuing year: President, Keith J. Evans; vice president, Julius Holl; secretary, D. F. Eastman; treasurer, J. B. Patterson.

The Engineers' Society of Western Pennsylvania will meet March 29th at the William Penn Hotel, Pittsburgh, to discuss "Coal Washing—Its Objects, Methods and Accomplishments." E. Paul Stewart, assistant chief engineer, Roberts & Schaefer Co., will be the speaker and will illustrate his paper with lantern slides.

Combustion Engineers who are connected with the iron and steel industry have been invited by the Association of Iron and Steel Electrical Engineers to become affiliated with the society. This move is for the purpose of broadening the field of the organization so as to take in completely the subject of electricity in steel work from the coal pile to the rolls.

The American Society of Mechanical Engineers has announced further plans for the Spring meeting. First there is to be an inspection trip to the McCook aviation field at Dayton, Ohio, on May 21. The meeting proper will be at Chicago on May 23-26. The fuel section plans to take as its main subject, "The Burning of Mid-Western Fuels," and plans to visit the new powdered-coal plant of the Milwaukee Electric Railway and Light Co. The power section expects to discuss "Power Resources and Development in the Middle West."

Miscellaneous News

A Large Steam-Electric plant at Fore River, Mass., is contemplated by the Edison Electric Illuminating Co. of Boston.

Water Power Legislation, as recommended by Governor Miller of New York, has been put before the state legislature in bills introduced by Senator Gibbs, of Buffalo, and Assemblyman Adler, of Rochester. It is planned to create a commission analogous to the Federal Power Commission, which would be empowered to make surveys and to issue licenses for water-power development work. An initial appropriation of $25,000 is provided. The regulation of capitalization and service is lodged with the Public Service Commission after the license has been given. Both bills were referred to committees and will be discussed in public hearings at an early date.

Business Items

The Blaw-Knox Co., Pittsburgh, Pa., has opened a new office at Kansas City, Mo., in charge of R. B. Randall, who is to be manager of the Southwestern territory.

The George T. Ladd Co., makers of water-tube boilers, has announced the appointment of J. B. Crane to the sales and engineering department. Mr. Crane has had over fifteen years' experience in the construction and operation of power houses.

The Underfeed Stoker Co. of America has made the following appointments to its branch office representation: The Merkle Machinery Co., 1733 Walnut St., Kansas City, Mo., with branches in Omaha and Tulsa; M. L. Alison, 616 Newhouse Building, Salt Lake City; Smith and Whitney, Southwestern Life Building, Dallas, Tex.

Trade Catalogs

The Files Engineering Co., Inc., Providence, R. I., is distributing a new folder describing briefly the Files stoker.

The Thwing Instrument Co., 3339-41 Lancaster Ave., Philadelphia, Pa., has put out a new 20-page bulletin, No. 10, describing electric indicating and recording pyrometers.

The Power Turbo-Blower Co., New York City, has recently issued a new 32-page, 6 x 9-in. catalog of turbo-blowers for furnaces and ventilation, and also describing small steam turbines.

The Nordberg Manufacturing Co., Milwaukee, Wis., has put out a new 28-page 8 x 10½-in. catalog describing the Nordberg Diesel engine, which is built in sizes from 200 to 4,000 hp. and is of the two-stroke-cycle type.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	Mar. 15, 1921	Mar. 22, 1921
Pocahontas,	Columbus	$3.50	$3.25
Clearfield,	Boston	2.50	2.00@3.00
Somerset,	Boston	3.00	2.40@3.60
Pittsburgh,	Pittsburgh	2.25	2.00@2.50
Kanawha,	Columbus	2.25	2.25
Hocking,	Columbus	2.25	2.15
Pittsburgh No. 8	Cleveland	2.15	2.00@2.25
Franklin, Ill.,	Chicago	2.85	3.25@3.50
Central, Ill.,	Chicago	2.00	1.50@2.50
Ind. 4th vein,	Chicago	2.65	2.25@3.00
Standard,	St. Louis	1.90	1.75@2.00
West Ky.,	Louisville	2.45	2.50
Big Seam,	Birmingham	2.95	2.95
S. E. Ky.,	Louisville	2.75	2.75

DIESEL FUEL OIL

New York—On March 23, Port Arthur "light," 23@25 deg. Baumé, f.o.b. Bayonne, N. J., 5¾c.

Chicago—24@28 deg. Baumé, $1.10@$1.20 per bbl.; 32@34 deg., 3¾@4¼c. per gal.

Cincinnati—In 8,000-gal. tank cars; 26@28 deg., 9¾c. per gal., 30@34 deg., 10c.

St. Louis—March 12 prices f.o.b. cars, tank lots: 24@30 deg. Baumé, 90c. per bbl.; 32@34 deg., 85c.; 16@20 deg., 3¾c. per gal.

Baltimore—On March 19, f.o.b. Baltimore in tank-car lots: 26@28 deg. Baumé, 7¾c.; 30@34 de., 7¾c.; 16@20 deg., 5.6c. per gal.

Pittsburgh—On March 14, f.o.b. refinery: 24@26 deg. Baumé, $1 per bbl.; 32@34 deg., 3c. per gal.; 36@38 deg., 3¾c.; 40@42c. deg. 4¼c. Pennsylvania, 36@40 deg. 5c.

New Construction

PROPOSED WORK

Mass., Falmouth—S. A. Holton, Secy. of Water Comrs., is in the market for 2 new H.R.T. boilers replacing present ones.

Mass., Lawrence—Toomey & Demara, are having plans revised for a 1 story, 110 x 125 ft. theater including a low pressure steam heating system on Bway. About $250,000. Blackall, Clapp & Whittemore, 20 Beacon St., Boston, Archts.

Mass., Medford—(Boston P. O.) The Bd. Educ. is having plans prepared for a 3 story high school with an assembly hall. About $350,000. T. M. James Co., 3 Park St., Boston, archt.

Mass., South Braintree—(Boston P. O.) The Monatiquot Rubber Wks. is having plans prepared for rebuilding its factory on Hancock St. which was destroyed by fire. Some large motors of various hp. capacity, will be installed in same. About $200,000. J. O. DeWolf Co., 45 Bromfield St., Boston, archt.

R. I., Providence — The State Penal & Charitable Comn. plans to build an infirmary building. About $450,000. Architect not yet selected.

Conn., Middletown—The Middlesex Hospital Com., 28 Crescent St., will soon award the contract for a 4 story, 40 x 100 ft. addition and alterations to present hospital buildings including a steam heating system. About $250,000. Buck & Sheldon Inc., 60 Prospect St., Hartford, archts.

Conn., New Britain—The Bd. Educ. plans to build a 3 story school on High St. About $250,000. Architect not yet selected.

N. Y., Attica—The village voted $28,000 bonds to extend present water system, construct reservoir, install pumping station, etc. Charles C. Hopkins, Cutler Bldg., Rochester, engr.

N. Y., Hempstead — The Marcus Loew Syndicate, 1493 Bway, New York City, plans to build a theater on Main St. between Fulton and Front Sts. About $450,000. Architect not yet selected.

N. Y., New York—(Manhattan Boro) The Bd. Educ., 500 Park Ave., received bids for furnishing and installing heating and ventilating equipment in P.S. 130 on Hester and Baxter Sts., from the Raisler Heating Co., 129 Amsterdam Ave., $78,099; Gillis & Geoghagan, 537 West Bway, $78,780; E. Rutzler Co., 404 East 44th St., $79,289. Noted March 15.

N. Y., New York—(Manhattan Boro) J. King, 116th St. and 3d Ave., plans to build a 3 story, 50 x 180 ft. theater including a steam heating system at 2176 3d Ave. About $400,000. E. DeRosa, 110 West 40th St., archt. and engr.

N. Y., South Fallsburg—The Civic League plans to build a water supply system and power house. Estimated cost, $100,000. A. Brickman, member of League.

N. J., Gloucester—The city is having plans prepared for reconstructing the waterwork and pumping station including pumps, filters, conveyor, oilers, etc. About $175,000. Remington & Vosbury, 6th and Market Sts., Camden, engrs.

N. J., Manumuskin—(Ormond P. O.) The C. I. DuPont DeNemours & Co., DuPont Bldg., Wilmington, Delaware, plans to build a 1 story black powder manufacturing plant including a power house, etc.

N. J., Millville—The Millville Light & Power Co. plans to build a 1 story addition to its power house. Large turbine engines, motors and generators will be installed in same. About $250,000.

N. J., Millville—The Millville Pulp & Pine Products Corp. is having plans prepared for a 1 and 2 story wood pulp and marine products plant, including a steam heating plant, motors and generators. J. W. Arthur, engr.

N. J., Trenton—The Trenton Poster Advertising Co. is having plans prepared for 3 story, 40 x 80 ft. factory, including a steam boiler, motors, etc. About $15,000. W. A. Klemmann, archt.

N. J., Vineland—The New Jersey Institution for the Feeble Minded is having plans prepared for a 1 story, 32 x 64 ft. boiler room and stack. About $21,500. F. H. Bent, 142 West State St., Trenton, archt.

Pa., Bakerstown — The Pittsburgh Cut Flower Co., 116 Sandusky St., Pittsburgh, plans to build a 45 x 70 ft. addition to its power house, here. About $30,000. W. J. Buckle, May Bldg., Pittsburgh, engr.

Pa., Johnstown — M. Nathan will soon award the contract for a 2 or 4 story, 90 x 120 ft. department store. About $250,000. W. J. Bickle, May Bldg., Pittsburgh, archt.

D. C. Washington—E. G. Walker, District Natl. Bank, will receive separate bids for an 8 story apartment house at 1812 K. St., N.W. About $500,000. F. R. White, 1410 G. St., N.W., archt.

N. C., Sims—The Neverson Granite Co. is in the market for a boiler.

Ga., Atlanta—The city voted $2,850,000 bond issue for improvements to the waterworks system to include additional pumps at the River station together with coal and ash handling equipment, etc.

Ga., Cordele—The city plans an election April 20 to vote on $50,000 for the construction of and putting into operation an electric light and power plant in connection with the water plant. J. Gordon Jones, Mayor.

Fla., Safety Harbor—The town plans an election April 5 to vote on $10,000 bonds for the purpose of purchasing electric lighting equipment. C. S. Washington, Mayor.

Fla., Sanford—The Lake Monroe Hotel Corp., c/o J. D. Hood, is having plans prepared for a 4 or 5 story, 75 x 100 ft. hotel including a steam heating system. About $500,000. F. H. Trimble, Orlando, archt.

La., New Orleans—The Gulf Machinery & Investment Co. is in the market for three 72 in. x 8 ft. H.R.T. boilers good for 150 lb. working steam pressure complete with Dutch oven fronts, stack, all fittings, etc.

La., New Orleans — B. Marcus Priteca, archt., 507, 509, 511 Pantages Bldg., Seattle, Wash., is receiving bids for a 6 story theater and office building on Canal and South Rampart Sts., here, for the Pantages Theater Circuit. About $1,500,000.

La., New Orleans—Stauffer, Eshleman & Co., Ltd., 11 Canal St., are in the market for domestic line of gasoline engines, diaphragm pumps, deep well pumps and force pumps also for contractors machinery and marine engines. Address H. N. Moore, mgr.

Ky., Prestonburg—The Bailey Ferguson Coal Co., S. C. Ferguson, Genl. Mgr., is in the market for engines, boilers, etc.

O., Bellefontain — The Patterson Monumental Wks. Co. is in the market for a 10 hp., 60 cycle, 3 phase, 220 volt motor and an 8 x 8 compressor (used).

O., Cleveland—The Bd. Educ. will receive bids until April 11 for installing a low pressure heating system at the Woodland school. W. R. McCormack, East 6th St. and Rockwell Ave., archt. Noted Feb. 8.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., received bids for installing a heating and ventilating system in the proposed 3 story, 220 x 332 ft. junior high school at Woodland Hills Park from the Feldman Bros., Barrett Ave., $129,500 and in the proposed 3 story, 220 x 335 ft. junior school on Hopkins Ave. and East 118th St., $129,500.

O., Dayton—The U. B. Publishing Co., 230 West 5th St., plans to build a 14 story, 40 x 160 ft. addition to office building on 4th and Main Sts. Cost, about $500,000. Architect not yet selected.

Ind., Ft. Wayne—Allen Co. Comrs. will receive bids for eleven 2 story infirmary buildings and a power plant. A steam heating system, stokers, conveyors, pumps, etc., will be installed in same. About $600,000.

Ind., Indianapolis—J. F. Concannon, 1327 Silver Ave., plans to build a 2 story, 70 x 110 ft. ice plant and slaughter house. About $40,000.

Ill., Alton—Edgar D. Martin, archt., 304 South Wabash Ave., Chicago, will receive bids until April 5 for a 2 story, 104 x 131 ft. hospital building, here for the State. About $500,000. G. A. Zeller, M. D., Mgr.

Ill., Quincy—The Michleman Steel Constr. Co., 137 North 2d St., will soon award the contract for a 2 story, 100 x 140 ft. manufacturing plant. About $500,000. W. S. Gerdes, engr.

Ill., Paris—The Paris Hotel Co. will soon award the contract for a 5 story, 54 x 80 ft. hotel. About $200,000. Nichol-Scholer & Hoffman, Ross Bldg., Lafayette, Ind., archts.

Ill., Winnetka—The Bd. Educ. will soon award the contract for a 2 story, 295 x 298 ft. school including a steam heating system on Elm St. About $450,000. Perkins, Fellows & Hamilton, 814 Tower Court, Chicago, archts.

Wis., Burlington—The Bd. of Pub. Wks. will soon award the contract for furnishing 300 g.p.m., motor driven centrifugal deep well pumps.

Wis., Milwaukee — The Wisconsin Ice & Coal Co., 216 West Water St., will receive bids this summer for a 1 and 2 story, 120 x 134 ft. ice manufacturing plant on Cambridge St. C. Ringer & Son, 432 Bway, archts.

Wis., Oconomowoc—F. R. Hubbard, Supt. of the Lighting Dept., will receive bids until April 4 for furnishing electrical equipment for street lighting system.

Wis., Park Falls—R. Fritz, City Clk., will receive bids for drilling one 10 in. bore deep well in connection with waterworks system. W. F. Reichardt, Watertown, engr.

Ia., Manning—The city plans to build an electric light plant. About $25,000 or more. H. C. Gaynor, Trimble Blk., Sioux City, engr.

Ia., Ottumwa—Croft Boerner, archt., 1006 Marquette Ave., Minneapolis, Minn., will receive bids until April 15 for a 4 story, 270 x 270 ft. school, for the Bd. Educ. About $800,000. A. Wagner, Secy.

Minn., Duluth—The St. Louis Co. Bd. Courthouse, is having plans prepared for a 3 story, 118 x 140 ft. county jail including a steam heating system on West 2d St. About $400,000. Halstead & Sullivan, Palladio Bldg., archts. and engrs.

Minn., Eveleth—The Bd. Educ. will receive bids until April 2 for a 3 story, 140 x 200 ft. grade vocational school including a steam heating system. About $750,000. J. M. Stearns, clk. W. T. Bray, 817 Torrey Bldg., Duluth, archt.

Kan., Morganville — The city plans an election April 4 to vote on $22,000 bond issue to build a transmission line. W. B. Rollins Eng. Co., Kansas, Mo., engr.

Kan., Wichita—The Bd. Educ. will soon award the contract for a 2 story, 77 x 94 ft. power house and a 2 story, 63 x 90 ft. auditorium and gymnasium on East Douglas St. Lorentz Schmidt & Co., 121 North Market St., archts.

S. D., Redfield—The city voted $125,000 bond issue for waterworks improvements including high water tank, pumps and extensions. About $125,000.

Wyo., Laramie—The Bd. of Trustees will receive bids until April 30 for a heating plant for the State University. About $90,000. E. G. Hoeffler, engr.

Wyo., Rawlins—The state is having plans prepared for a 2 story power house on the Penitentary Grounds here. About $70,000. W. Duboice, Cheyenne, archt.

Wyo., Wheatland—The town will receive bids until April 4 for material and labor for the extensions and improvements of the sanitary sewer system to include a sludge pump, etc. also an air compressor and one 30 hp., 2,300 volt, 3 phase, a.c. motor, etc. in connection with the water works improvements.

Mo., Medill—The Producers Cold Storage Co. is having plans prepared for a 3 story, 63 x 108 ft. packing plant. About $50,000.

Mo., St. Joseph—The Bd. Educ. plans an election April 2 to vote on $1,700,000 bonds for 3 school buildings.

Mo., St. Louis — J. P. Jamison, Archt., Security Bldg., will receive bids until April 15 for a 2 story, 54 x 188 ft. commerce and finance building on Skinker Rd. and Forsythe Ave., for the Washington University, Skinker Rd. and Lindell Ave. About $300,000.

Mo., St. Louis—V. J. Klutho, Archt., Syndicate Trust Bldg., will receive bids April 1 for a 4 story, 72 x 175 ft. college with a 72 x 95 ft. wing addition, for the Society of St. Mary. About $400,000.

Cal., Fullerton—The city received bids for furnishing and installing 2 booster pumps, 900 gal. per minute, two 100 hp. motors, 2 deep well pumps, two 40 hp. motor, reducers, valves and pipes and erecting 2 derricks, (1) equipment and (2) installation, from the Amer. Pump Co., 227 Marsh Strong Bldg., Los Angeles (1) $16,291 (2) $13,527; Byron Jackson Pump Co., 336 East 3d St., Los Angeles, (1) $12,566 (2) $12,200; T. Haverty Co., 8th St. and Maple Ave., Los Angeles, (1) $13,600 (2) $12,850 deep well pumps and motors not included in this bid. Noted March 9.

Cal., Hollywood (Los Angeles P. O.)—The town plans an election April 5 for the purpose of voting on a proposed bond issue of $1,500,000 for a street lighting system.

N. S., Amherst—The town is having estimates made of the cost of an electric light and power plant. C. D. Shipley, Mayor.

Que., Sherbrooke—The Wright Bros., 53 Fontenac St., are in the market for motors and transformers.

Ont., Belleville—The Provincial Government of Ontario plans to expend $10,000 for stand pipe, new pump and intake pipe for the water supply system at the school for the deaf, here.

Ont., Hamilton—The Provincial Government of Ontario plans to expend $6,500 for an auxiliary centrifugal pump at the Queen St. Station, here.

Ont., Kingston — The Provincial Government of Ontario plans to expend $7,500 for a cold storage plant at the Hospital, here.

Ont., Mimico—The Town Council passed a by-law authorizing extensions and additions to sewage system, pumphouse addition and new sewage low lift pumps. About $50,000. Bids will be received for electric operated sewage pumps, to have a 1,500 and 2,000 g.p.m. capacity.

Ont., Sudbury — Supt. Martindale, c/o Waterworks Comn., will soon receive bids for an electric driven, 1,000 g.p.m, centrifugal pump for the pumphouse. About $7,000.

Ont., Thedford — The Council plans to build an electric lighting system and is in the market for equipment. About $15,000. W. Brooks, Engr.

Ont., Toronto—R. C. Harris, City Hall, City Engr., plans to install two 250 hp. boilers, one 500 hp. turbo generator and construct a boiler and engine house at the Riverdale pumping station. About $100,000. Noted Dec. 14.

Ont., Toronto—James, Proctor & Redfern Ltd., Engrs., 36 Toronto St., will receive bids until March 31 for a low lift pumphouse, etc. About $125,000.

Ont., Toronto—The University of Toronto plans to build a 1 story artificial ice hockey arena including a steam heating system and electric motors. About $450,000.

Ont., Windsor — The Neal Baking Co. plans to build a bakery. About $250,000. Architect not yet selected.

T. H., Pearl Harbor — The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will receive bids May 11 for water and sewerage systems including two motor driven pumping units, etc. and steel buildings including 2 shops, 2 pump houses, etc., at the Naval Air Station, here.

CONTRACTS AWARDED

Conn., Avon—The Pope Memorial School, c/o Theodore Pope, archt. and engr., 402 Madison Ave., New York City, will build a school. About $1,000,000. Work will be done by day labor.

N. Y., New York—(Manhattan P. O.) J. Tishman & Sons Inc., 18 East 41st St., will build a 9 story, 100 x 100 ft. apartment house including a steam heating system at 110 West 55th St. About $850,000. Work will be done by day labor.

N. Y., New York—(Manhattan Boro) The Tway Bldg. Corp., 135 Bway, will build a 6 story apartment house including a steam heating system on Fort Washington Ave. and 171st. St. About $300,000. Work will be done by day labor.

N. Y., New York—(Manhattan Boro) The United Electric Light & Power Co., 130 East 15th St., has awarded the contract for a 3 story, 30 x 100 ft. sub-station at 115 West 98th St., to James A. Henderson, 103 Park Ave. Estimated cost, $175,000.

N. Y., Tompkinsville—(Staten Island P. O.) The Amer. Dock Terminal, 17 State St., New York City, has awarded the contract for a 7 story, 125 x 160 ft. warehouse including a steam heating system, to the Turner Constr. Co., 242 Madison Ave., New York City.

N. J., Atlantic City—The Amer. Gas & Electric Co., 30 Church St., New York City, will build an addition to its power plant, here. About 800,000. Work will be done by day labor.

S. C., Spartanburg—The City has awarded the contract for a high school including a steam heating system, etc., to Palmer & Spivey, Campbell Bldg., Augusta, Ga., at $213,125.

Ga., Columbus—The Central of Georgia Ry. Co., Savannah, has awarded the contract for the installation of a direct radiation vacuum steam heating system in its roundhouse here, to the Kehm Bros. Co., 13 West Kinzie St., Chicago, Ill., at $16,000.

La., St. Rose—The Petroleum Import and Export Corp. Inc., a subsidary of the Carson Petroleum Co., has awarded the contract for a 40 x 60 ft. pump house, 60 x 90 ft. power house, 40 x 70 ft. boiler house and several other buildings, here, to R. P. Farnsworth, St. Charles and St. Andrews Sts., New Orleans, at $200,000.

O., Cleveland—The city has awarded the contract for furnishing a boiler feed water heater, to the Ohio Body & Blower Co., Detroit Ave., at $4,442. Noted March 22.

Ohio, Glendale—The village has awarded the contract for a plant, to John H. McGowan Co., 910 4th Natl. Bank Bldg., Cincinnati, at $3,648. Two 6 x 10 in. horizontal duplex pumps, two 25 hp. squirrel-cage, 220 volt, 60 cycle motors and 2 diaphragm pressure regulators will be installed in same.

Ind., Indianapolis—The Polar Ice & Fuel Co., 20th St. and Northwestern Ave., has awarded the contract for a 1 story, 48 x 84 ft. ice plant, to W. P. Jungelaus Co., 825 Massachusetts Ave. About $40,000. Noted March 15.

Wis., Fond du Lac—The Bd. Educ. has awarded the contract for a 3 story, 200 x 250 ft. high school on Main St., to the Immel Constr. Co., 200 North Main St. at $800,000. Bids for installing heating system, etc. will be received until April 7.

Wis., Two Rivers — The Bd. Educ. has awarded the contract for installing a steam heating system in the proposed 4 story, 60 x 200 ft. high school on Main St., to G. H. Kallies, Manitowoc.

Mo., Moberly—The city has awarded the contract for a pumping station, etc., to Lynch & McDonald at $224,005.

Tex., San Antonio—The Gebhardt Chili Powder Co. has awarded the contract for a 2 story, 42 x 135 ft. building including refrigerating system, etc., to Coleman & Jenkins, Gunther Bldg., at $39,770.

Okla., Talihina—The State has awarded the contract for a 2 story, 43 x 135 ft. and 49 x 189 ft. tuberculosis hospital, to the Manhattan Constr. Co., Muskogee, at $91,000. A central power plant to have a 400 hp. capacity will be installed later.

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